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**Park et al.**

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(54) **LIQUID CRYSTAL DISPLAY AND MANUFACTURING METHOD THEREOF**

G02F 2202/02 (2013.01); G02F 2202/36 (2013.01); G02F 2203/055 (2013.01)

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See application file for complete search history.

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(30) **Foreign Application Priority Data**

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*Primary Examiner* — Nathanael R Briggs

(74) *Attorney, Agent, or Firm* — F. Chau & Associates, LLC

(51) **Int. Cl.**

G02F 1/1335 (2006.01)

G02F 1/1333 (2006.01)

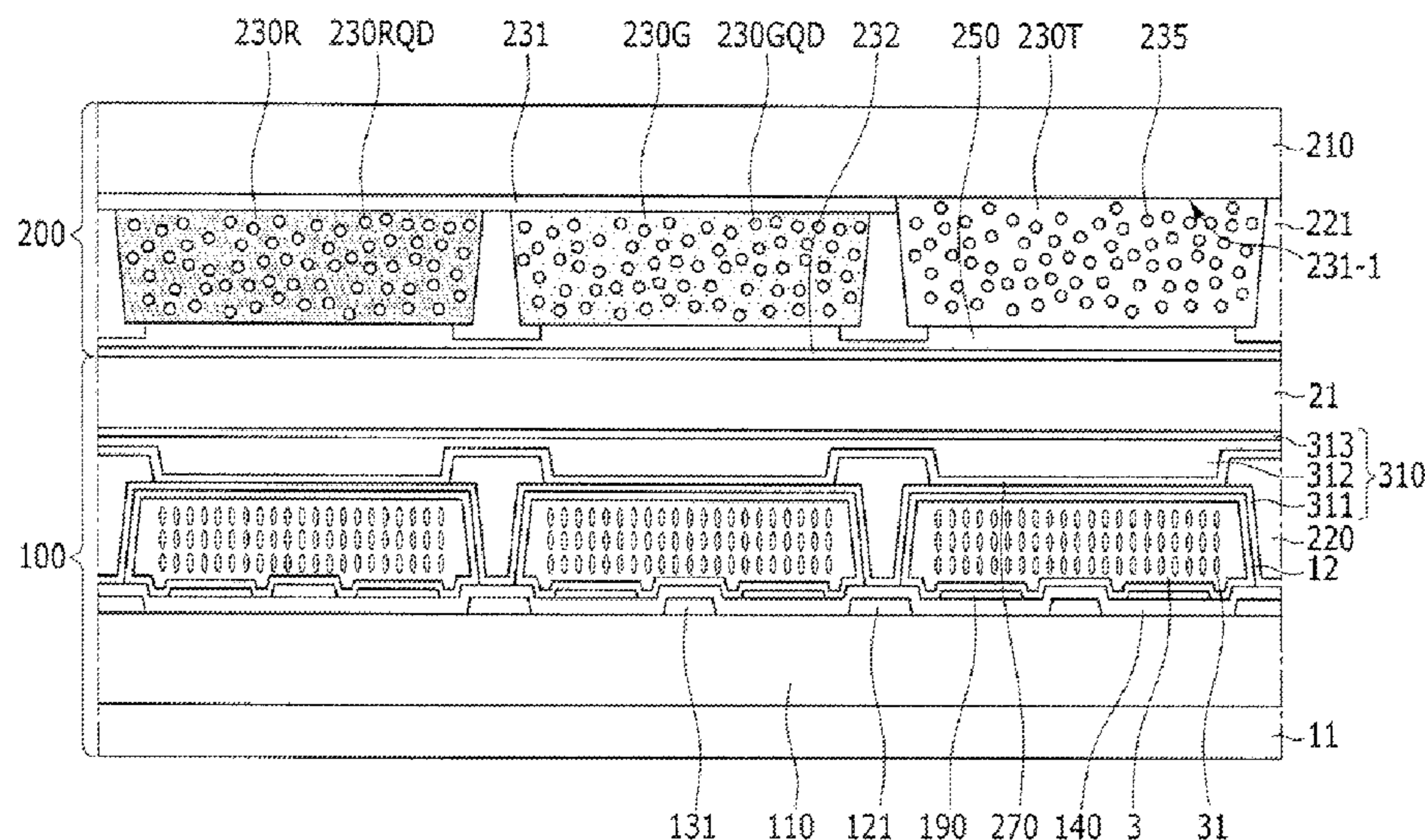
(52) **U.S. Cl.**

CPC .. G02F 1/133514 (2013.01); G02F 1/133377 (2013.01); G02F 1/133528 (2013.01); G02F 1/133617 (2013.01); G02F 2201/08 (2013.01);

(57) **ABSTRACT**

A wide viewing angle liquid crystal display includes color filters having a quantum dot and scattering particles and liquid crystal layer disposed in a microcavity, a distance between the color filter and the liquid crystal layer being sized to minimize display deterioration due to parallax.

**11 Claims, 35 Drawing Sheets**



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FIG. 1

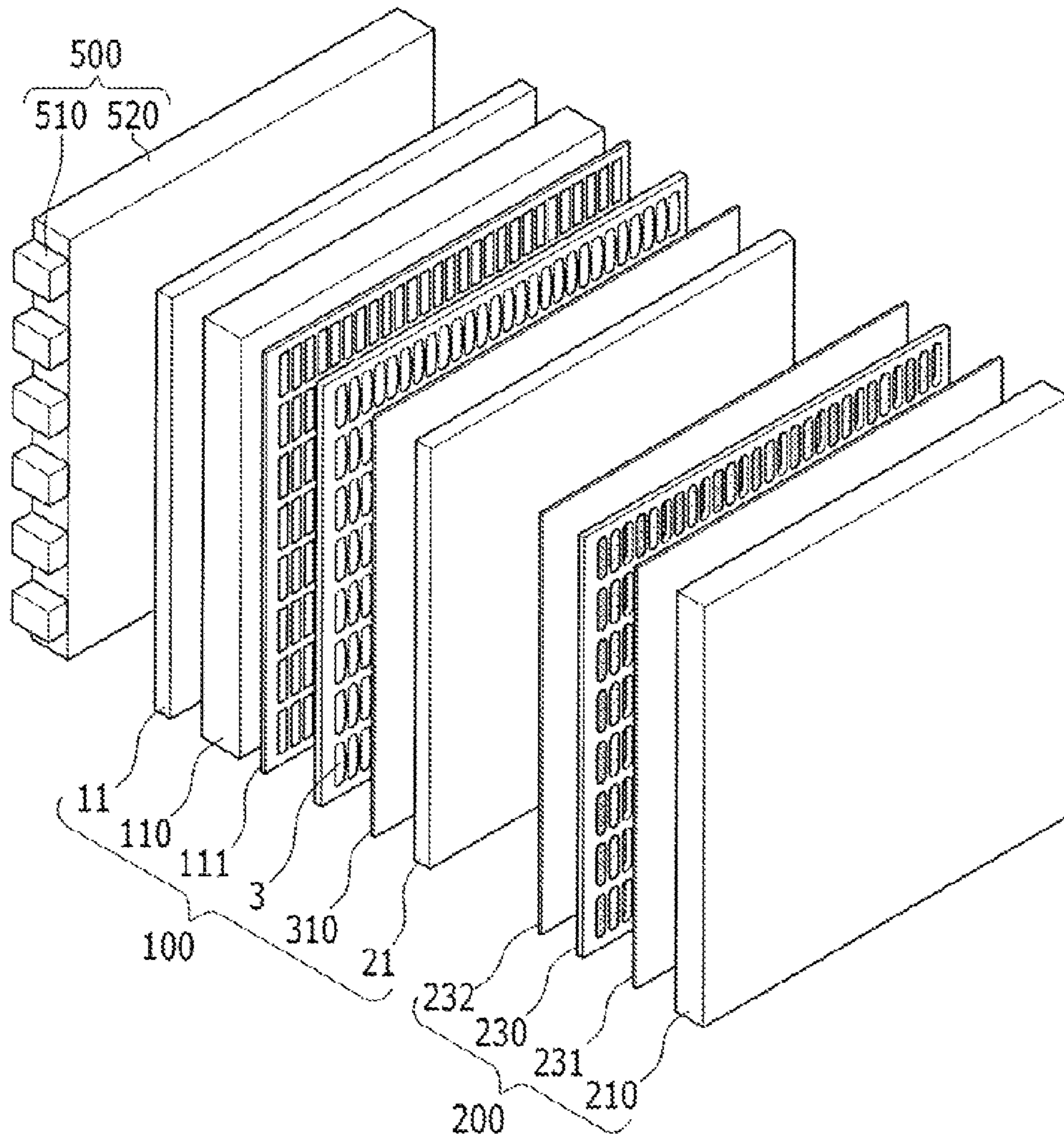






FIG. 3

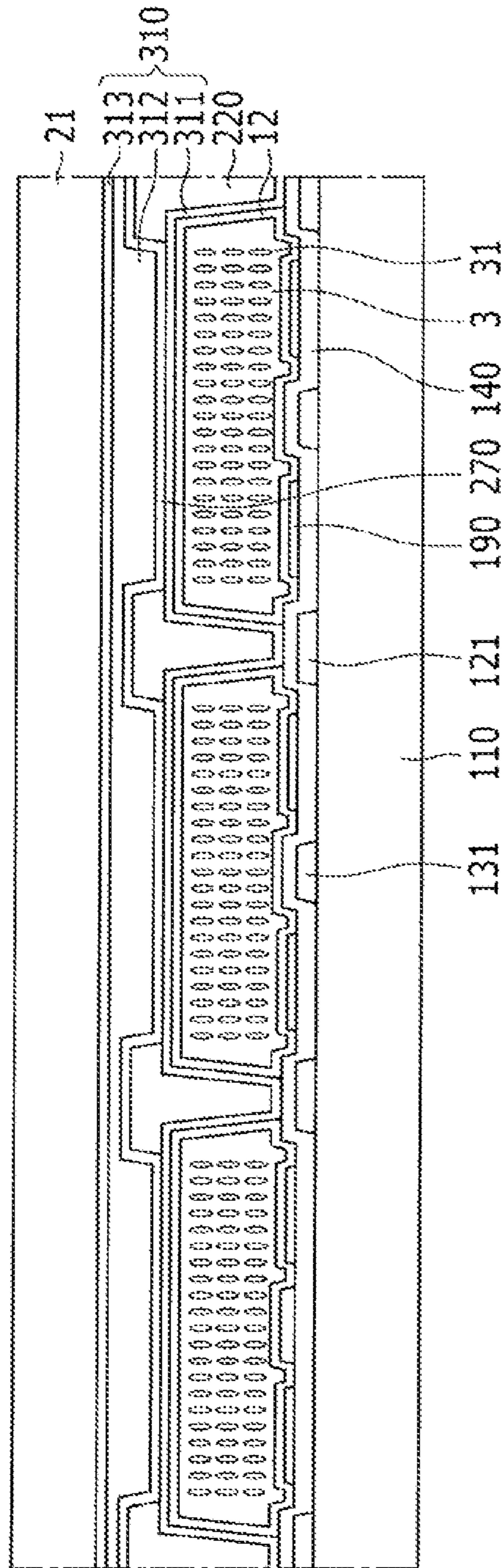


FIG. 4

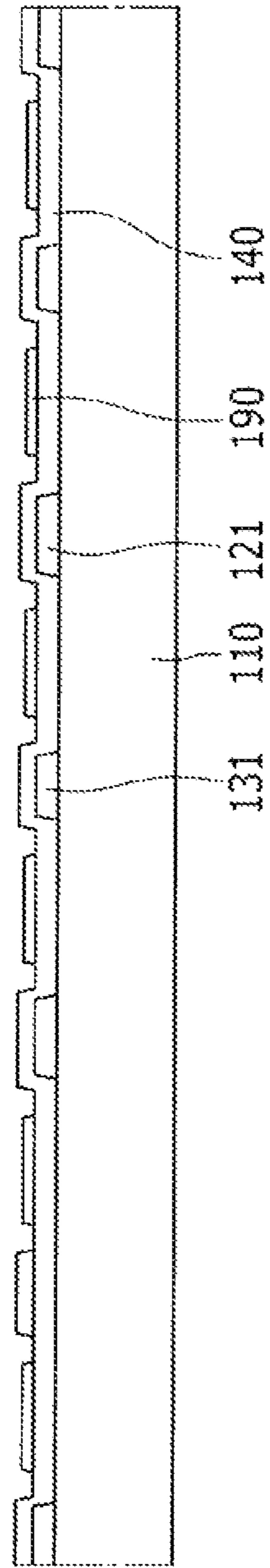


FIG. 5

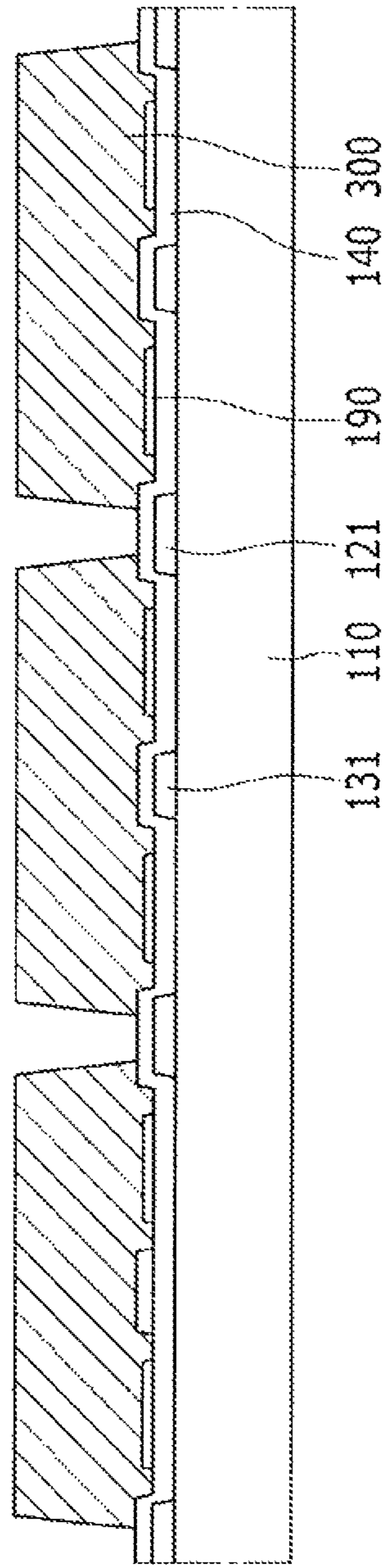


FIG. 6

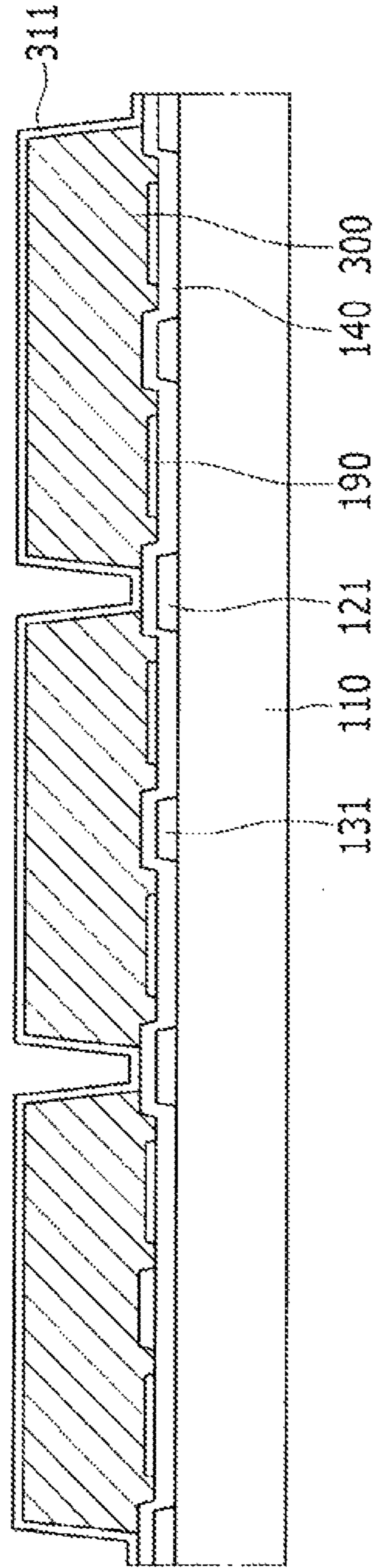




FIG. 7

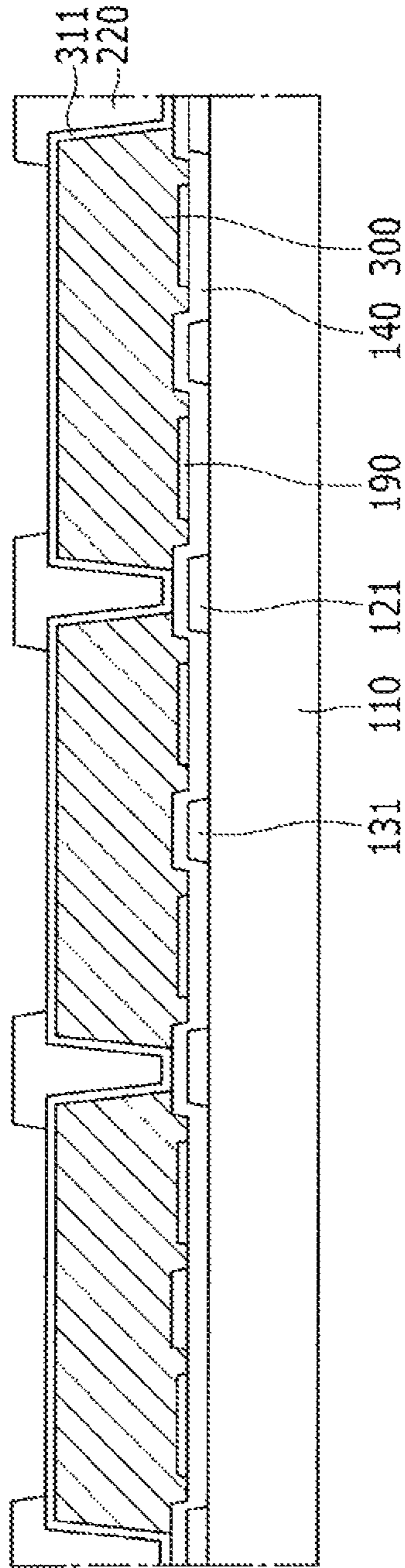


FIG. 8

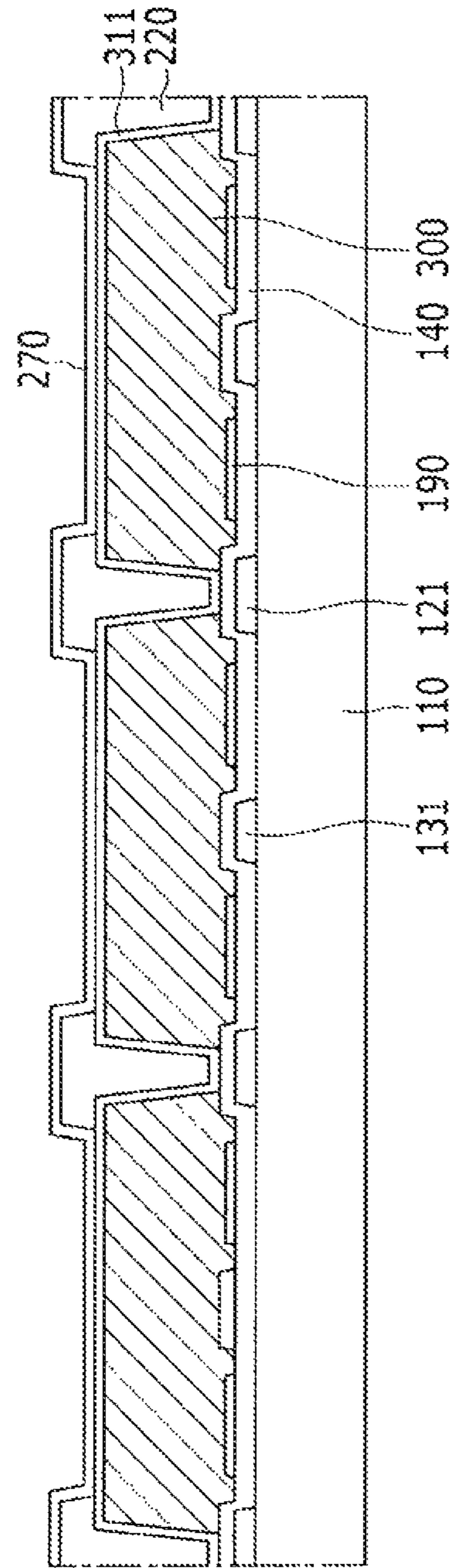


FIG. 9

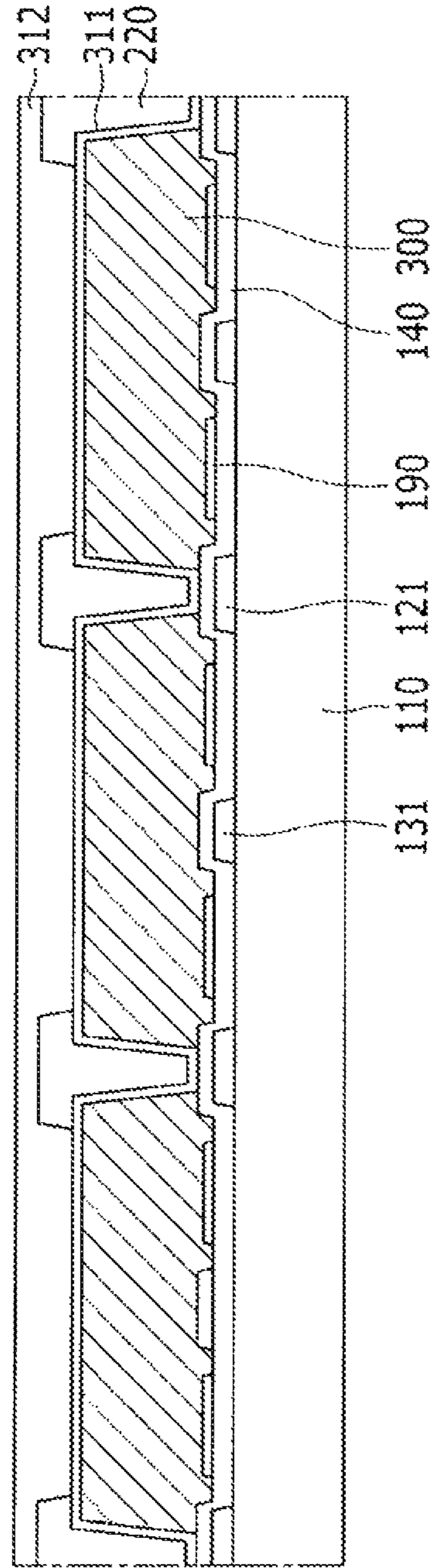


FIG. 10

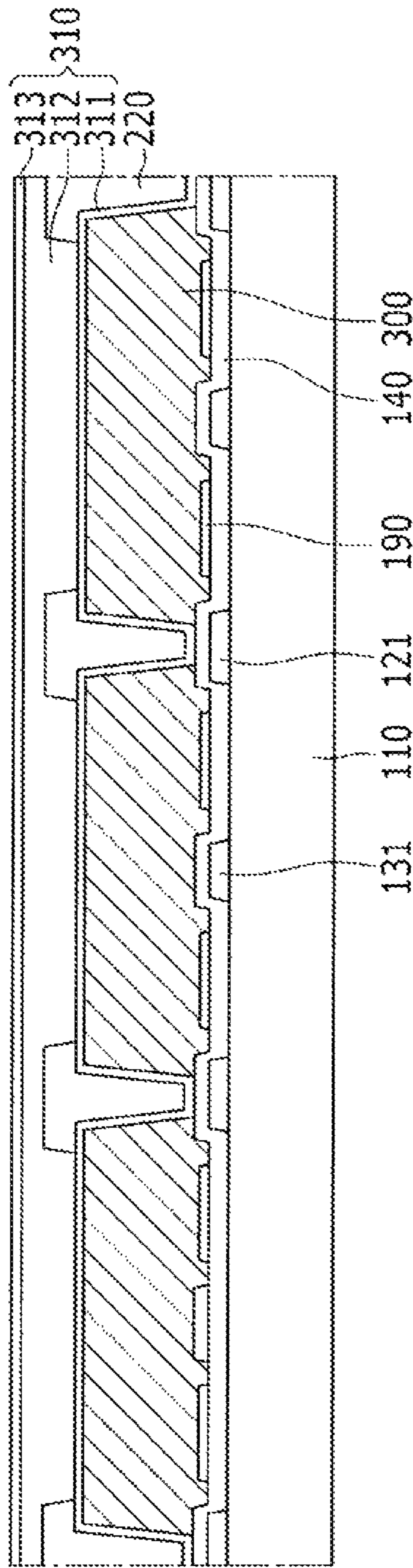




FIG. 11

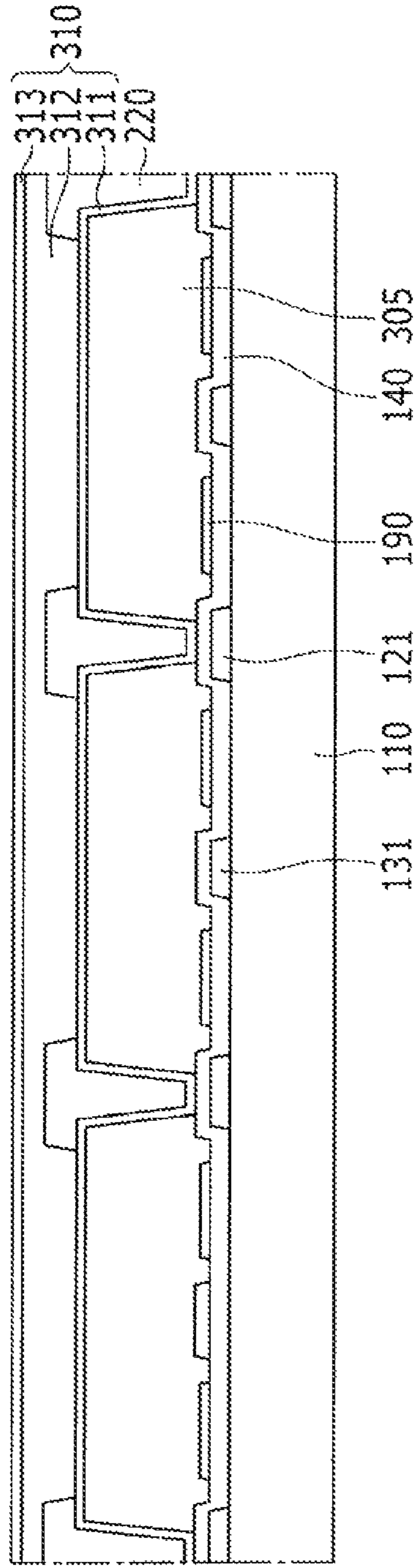


FIG. 12

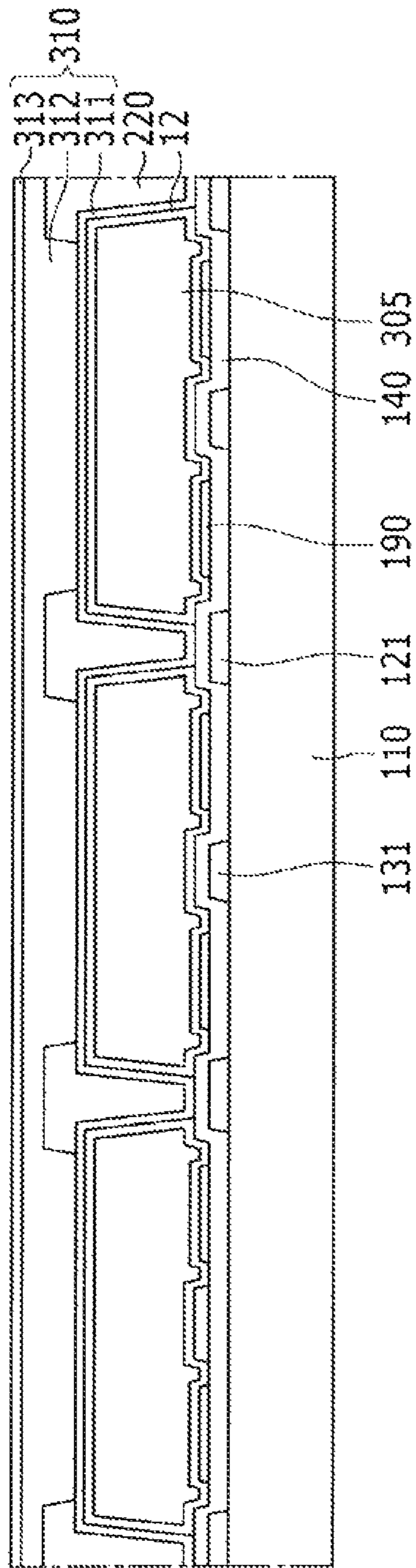


FIG. 13

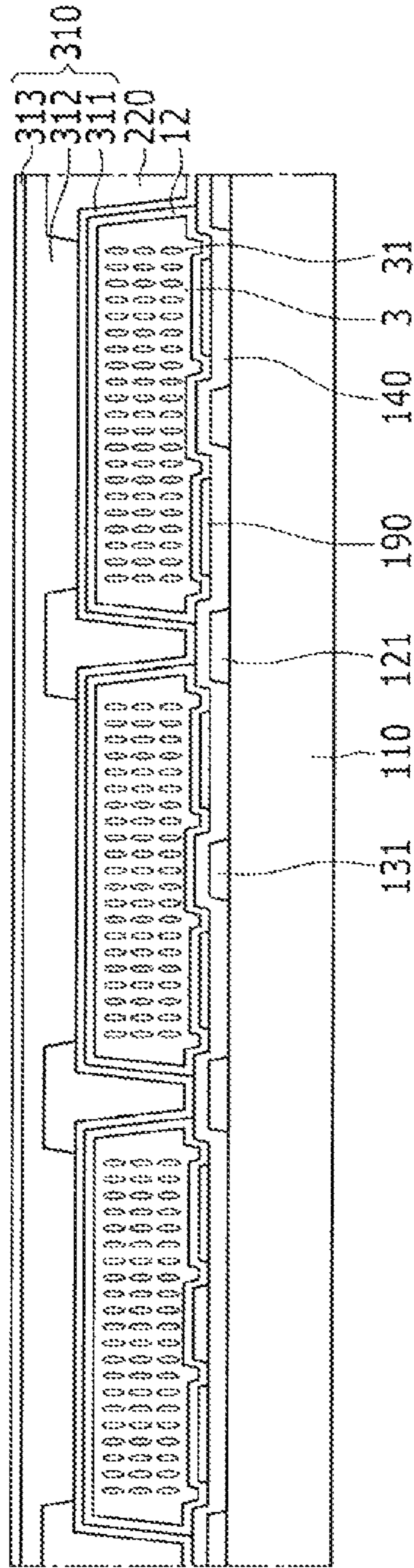


FIG. 14

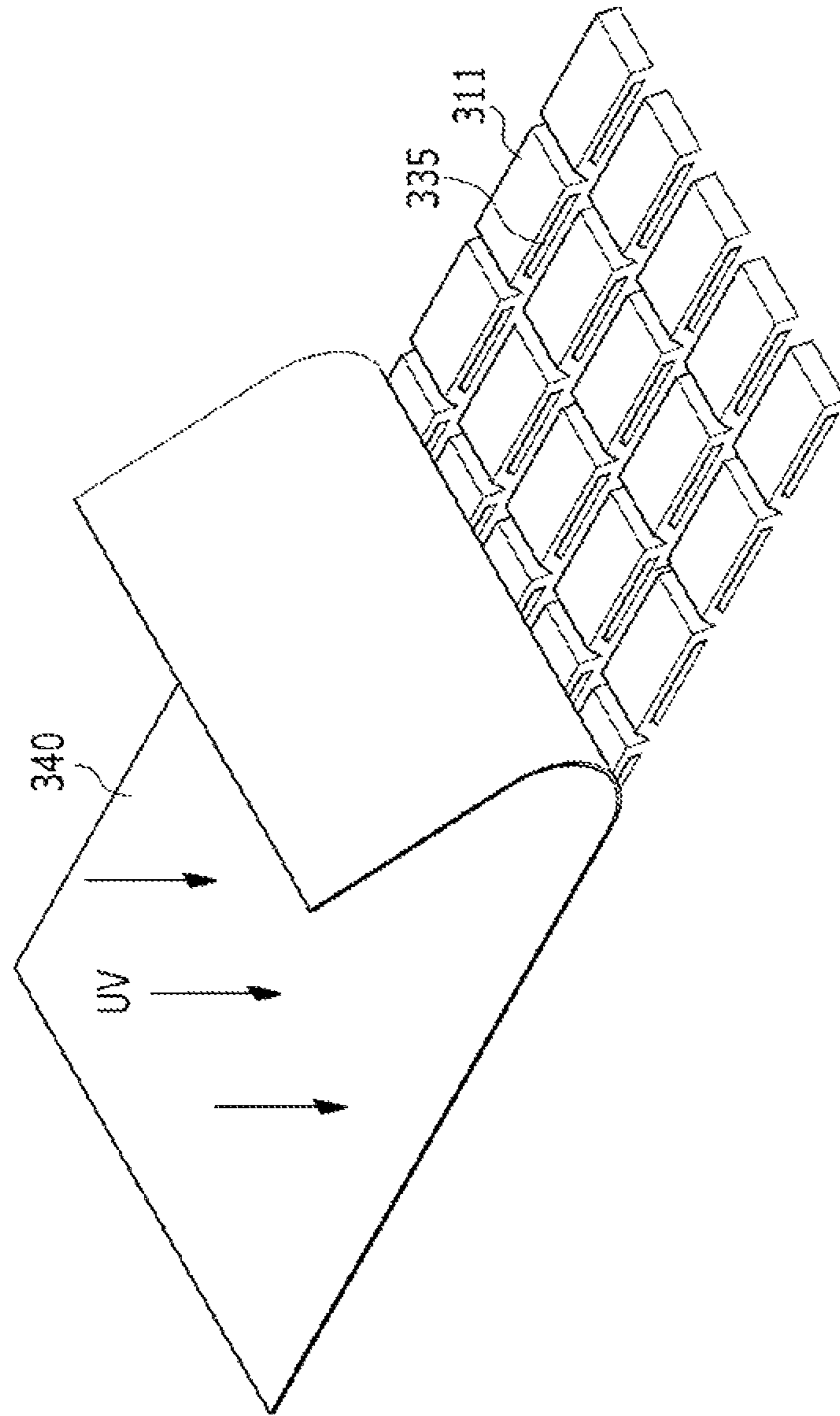




FIG. 15

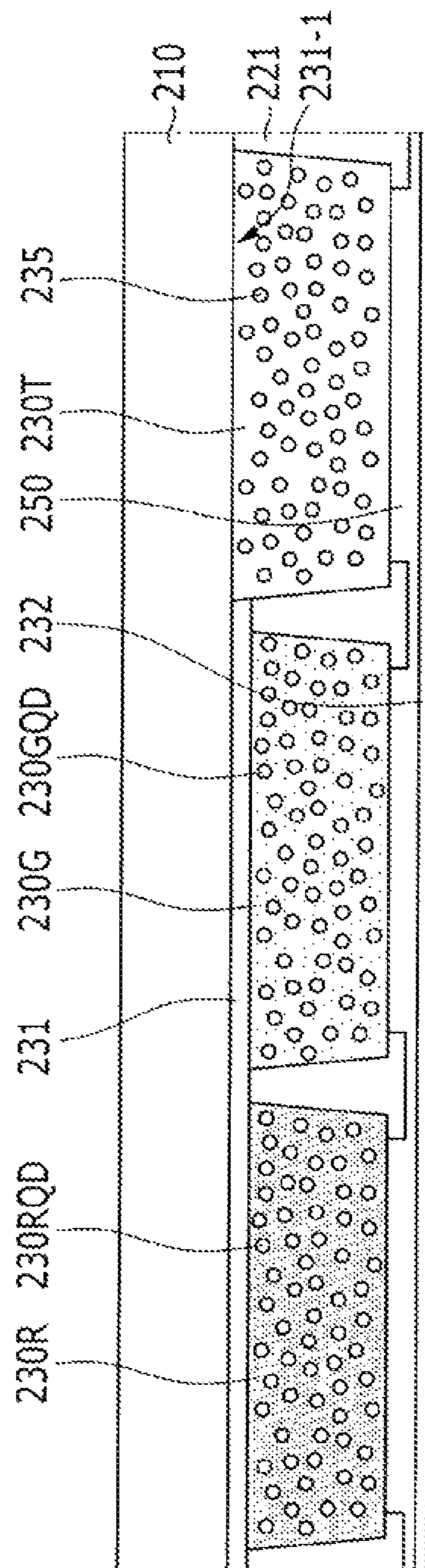


FIG. 16

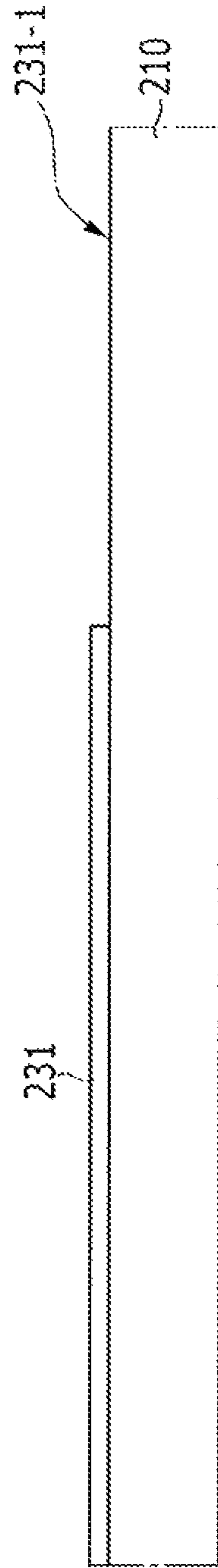


FIG. 17

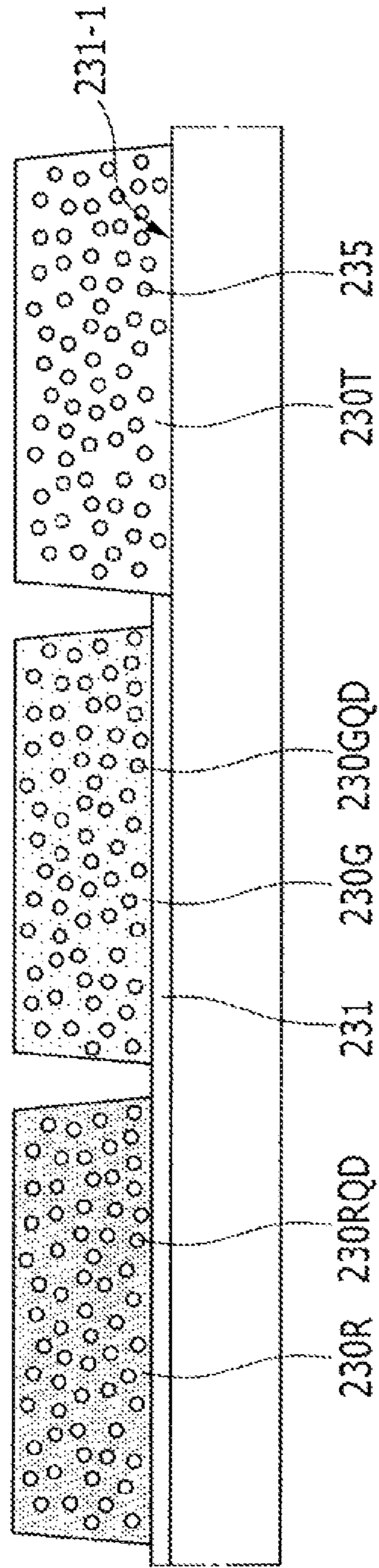


FIG. 18

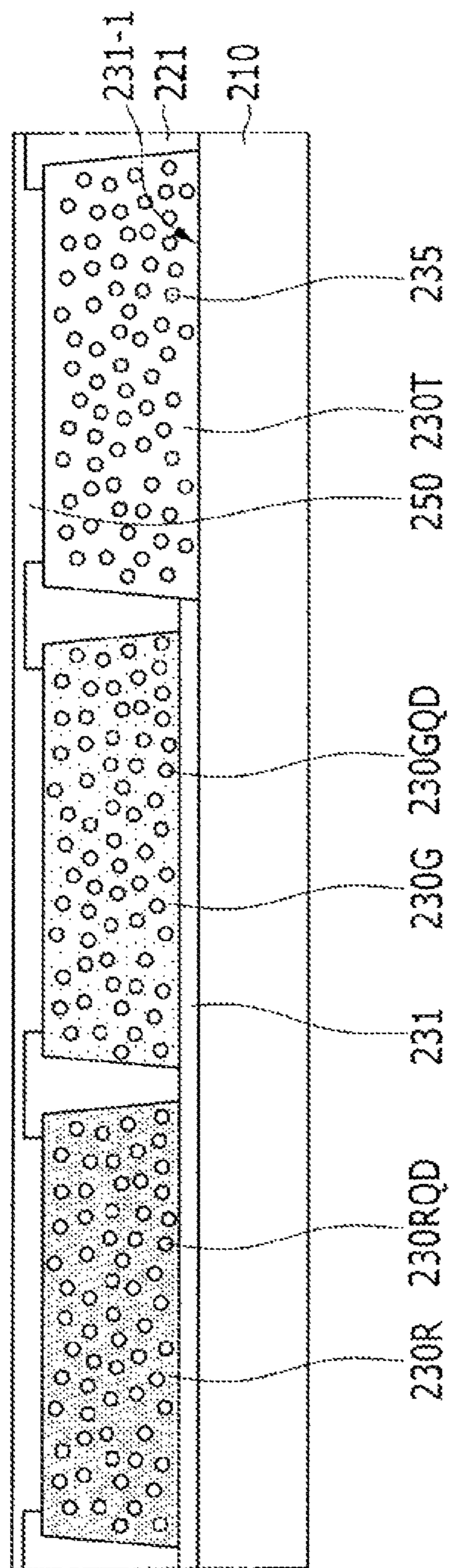




FIG. 19

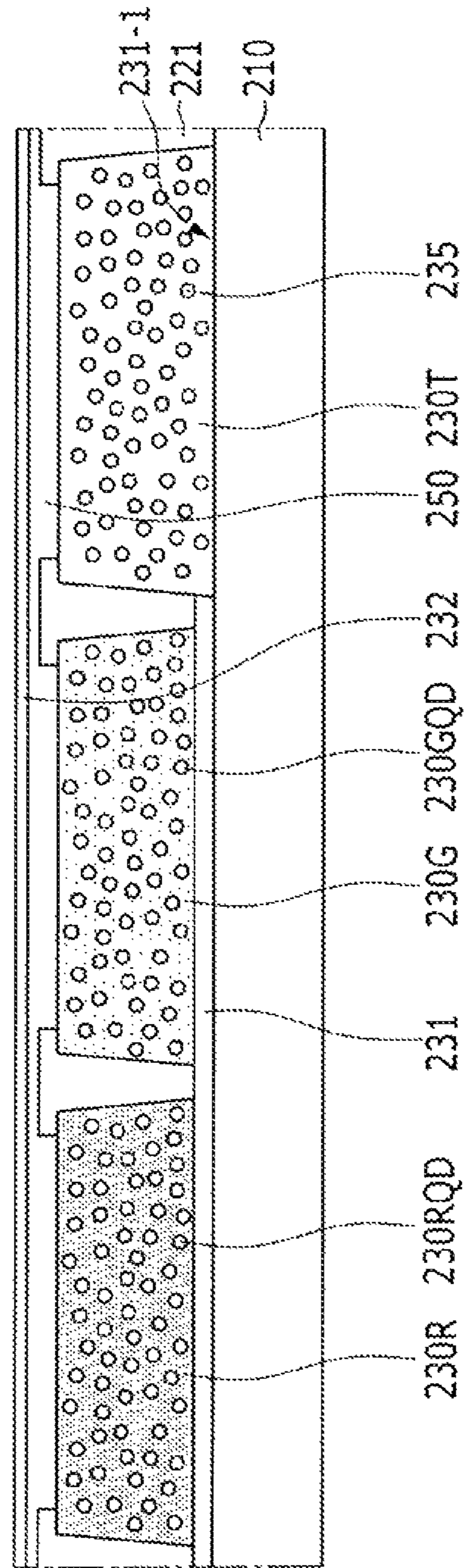


FIG. 20

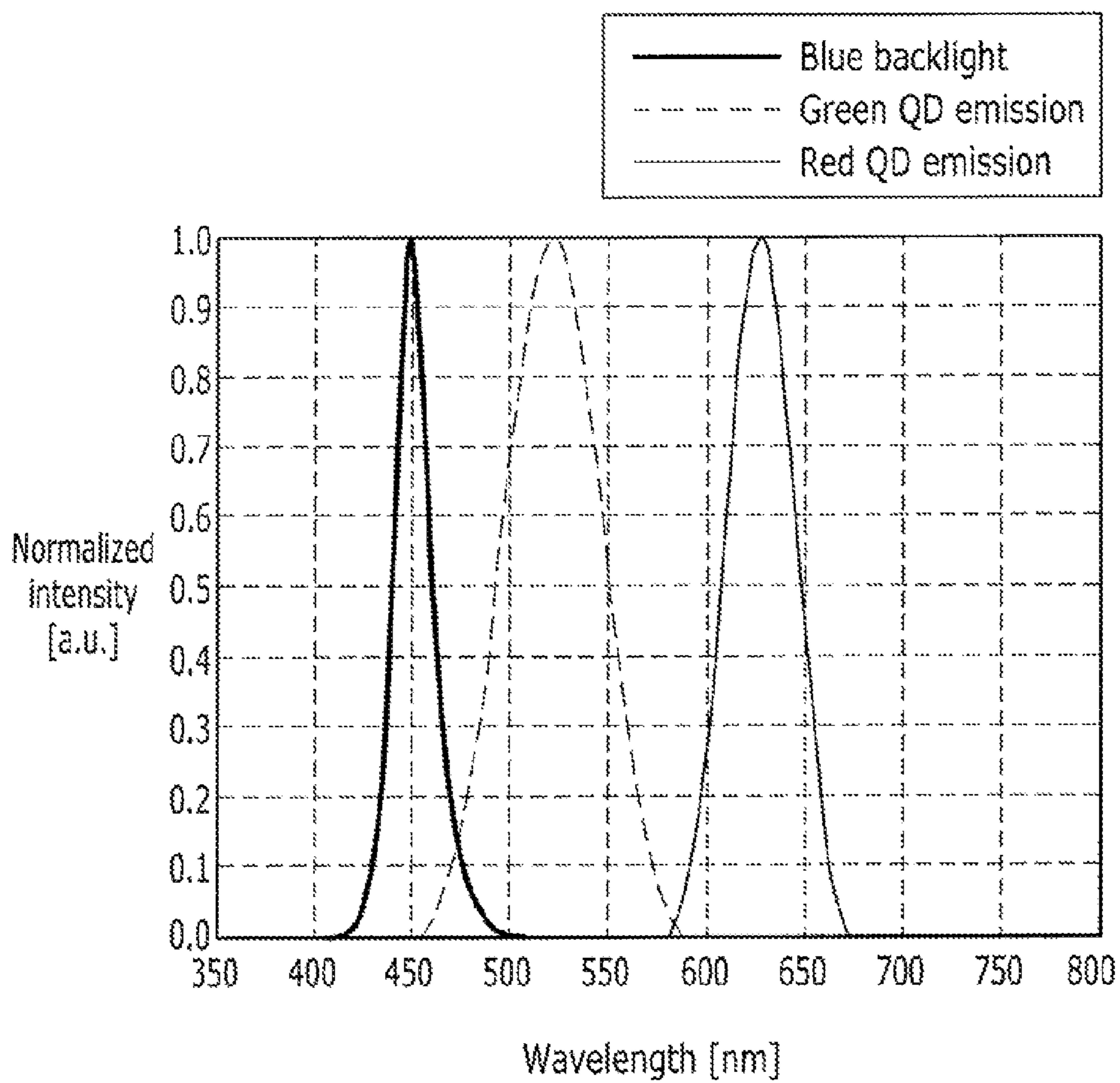


FIG. 21

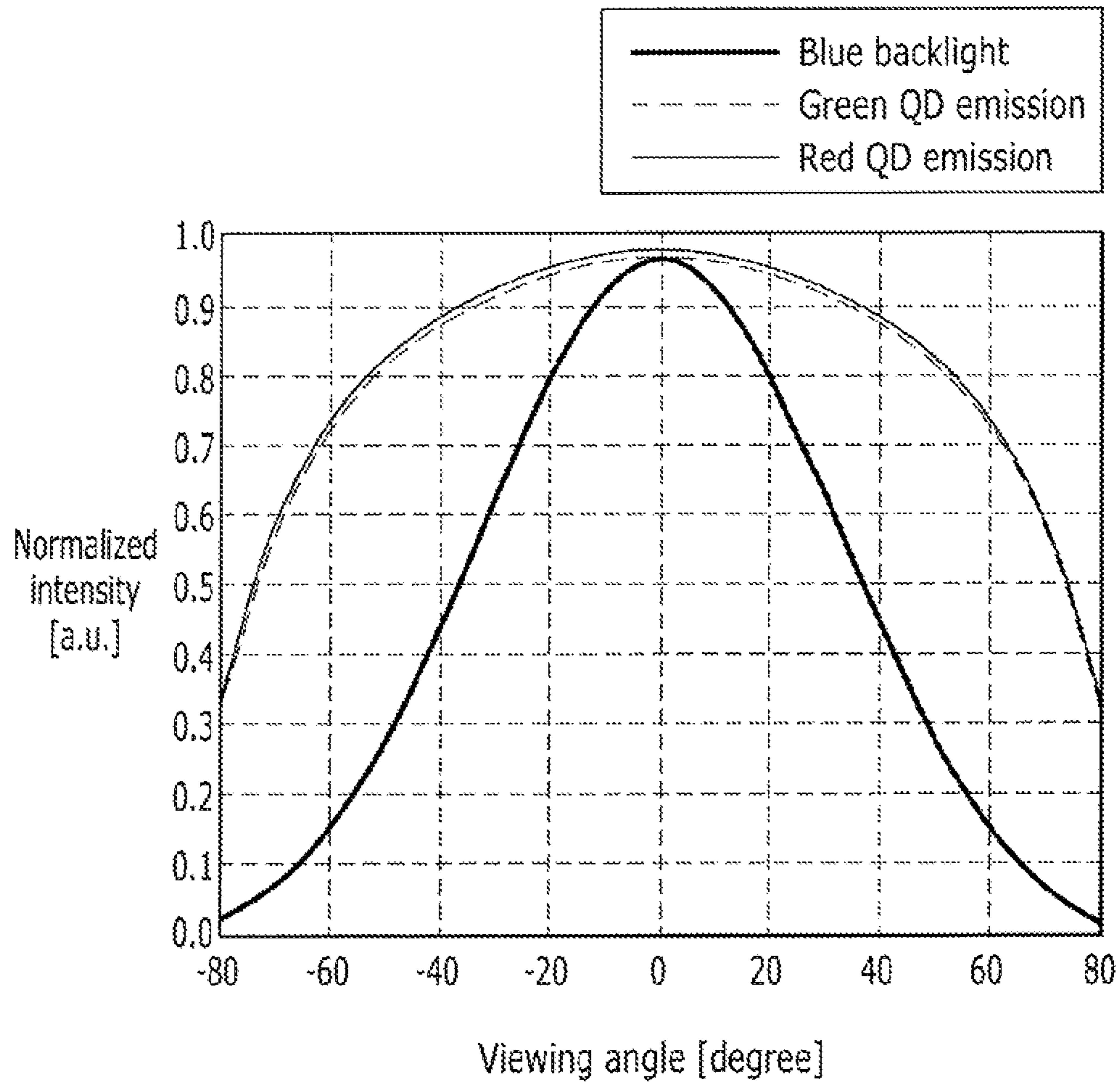


FIG. 22

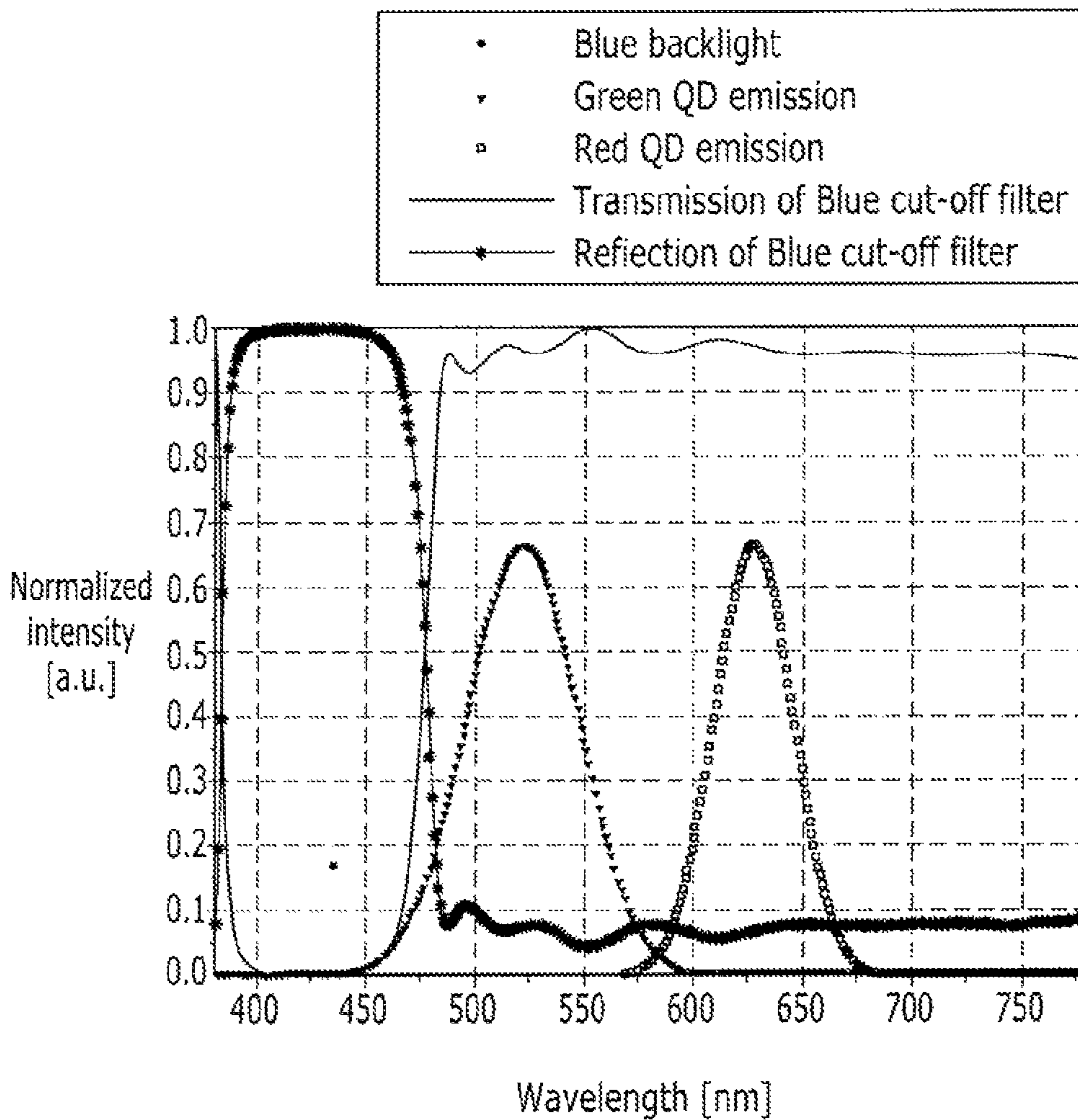




FIG. 23

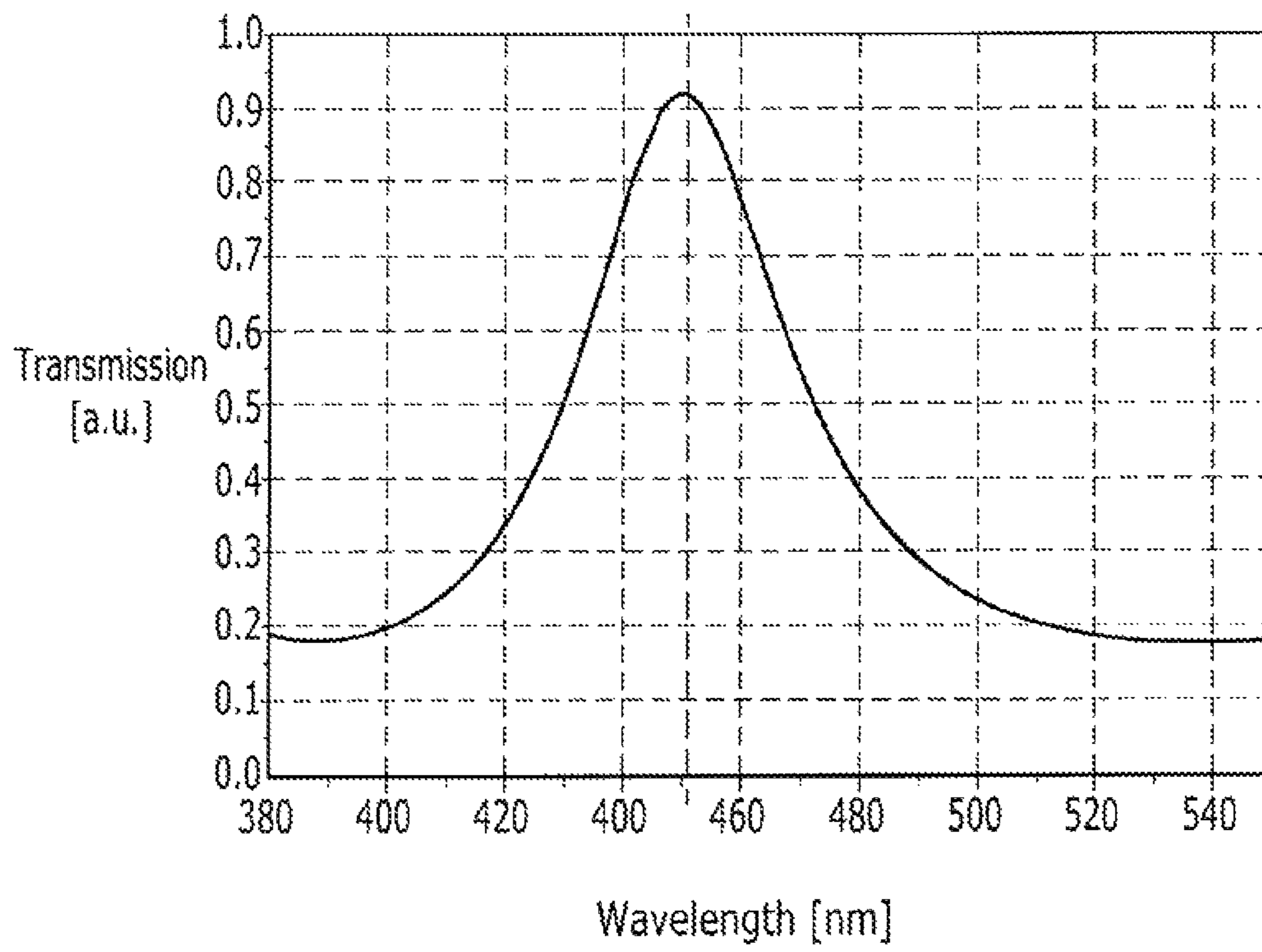


FIG. 24

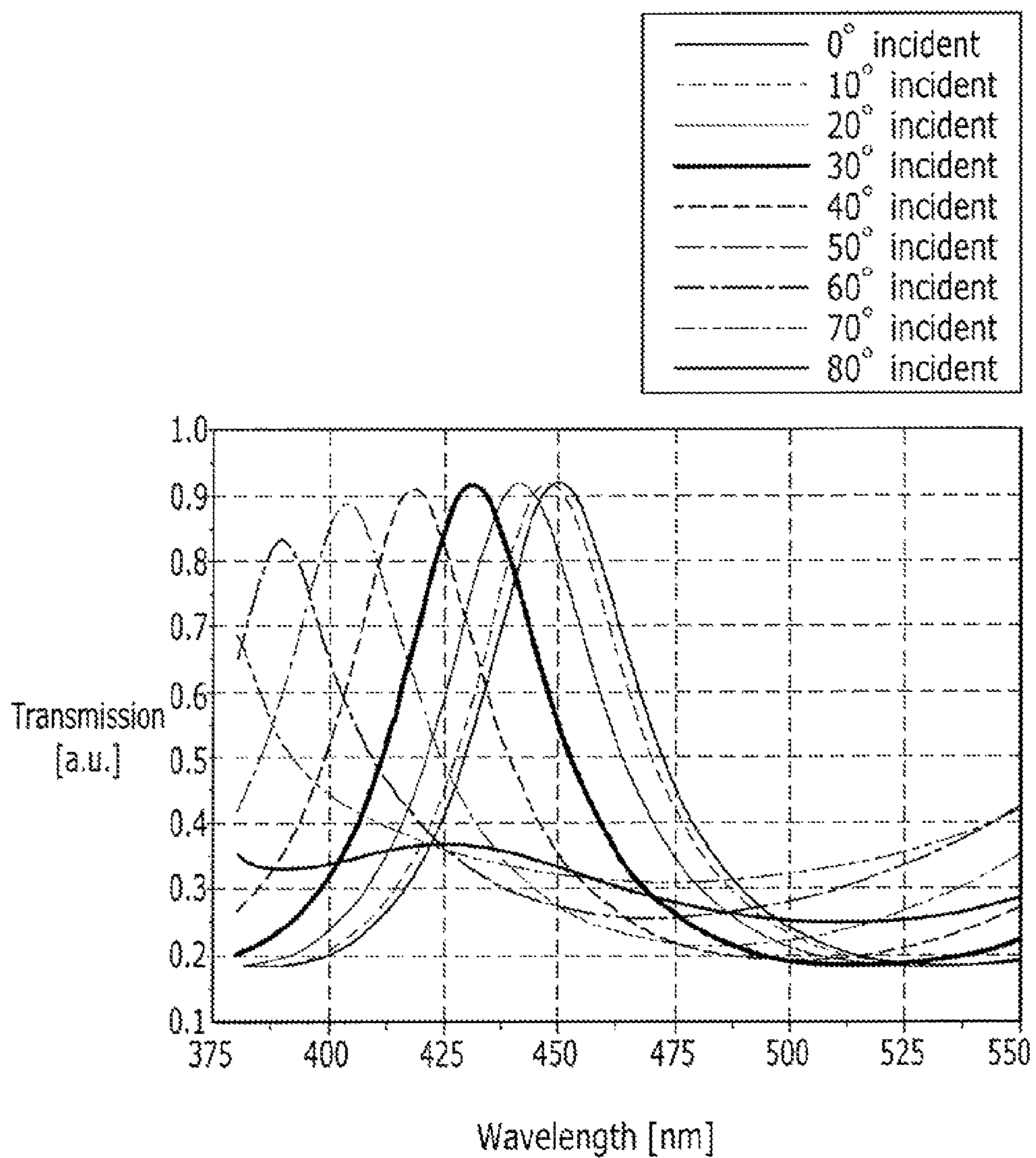




FIG. 26

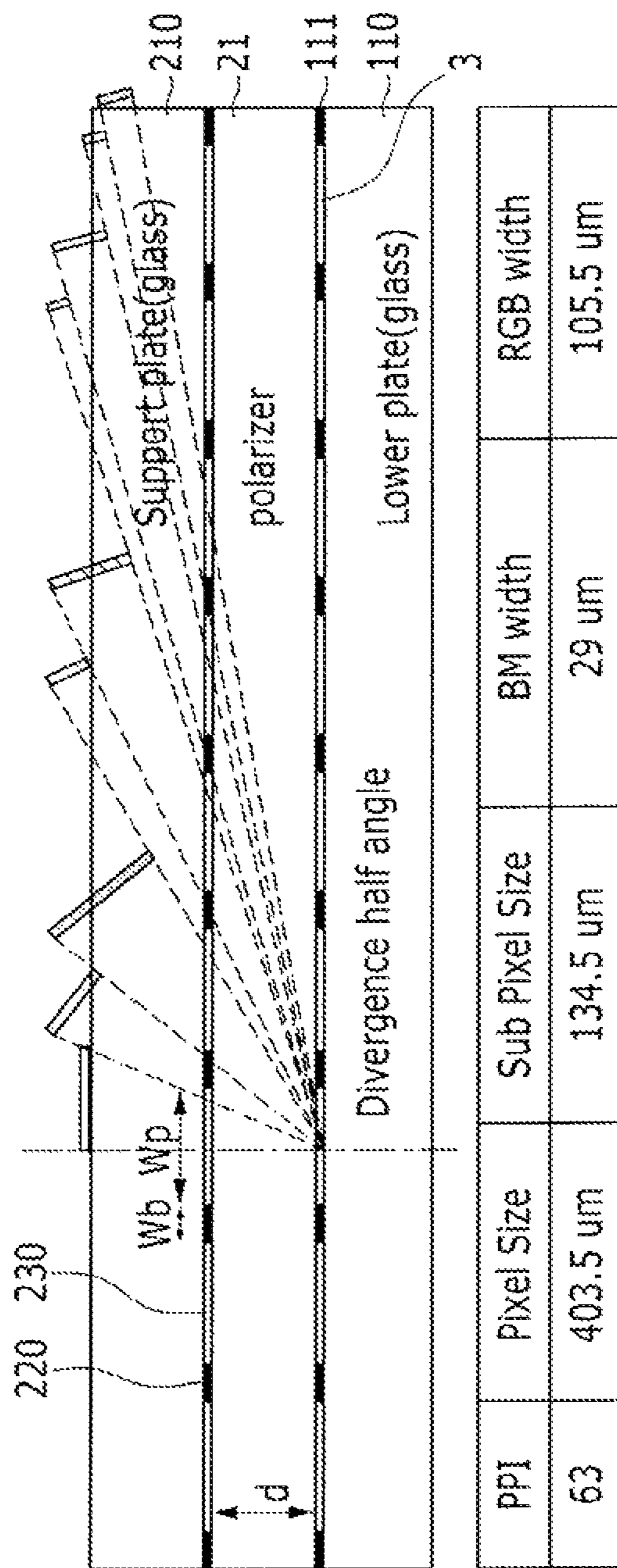


FIG. 27

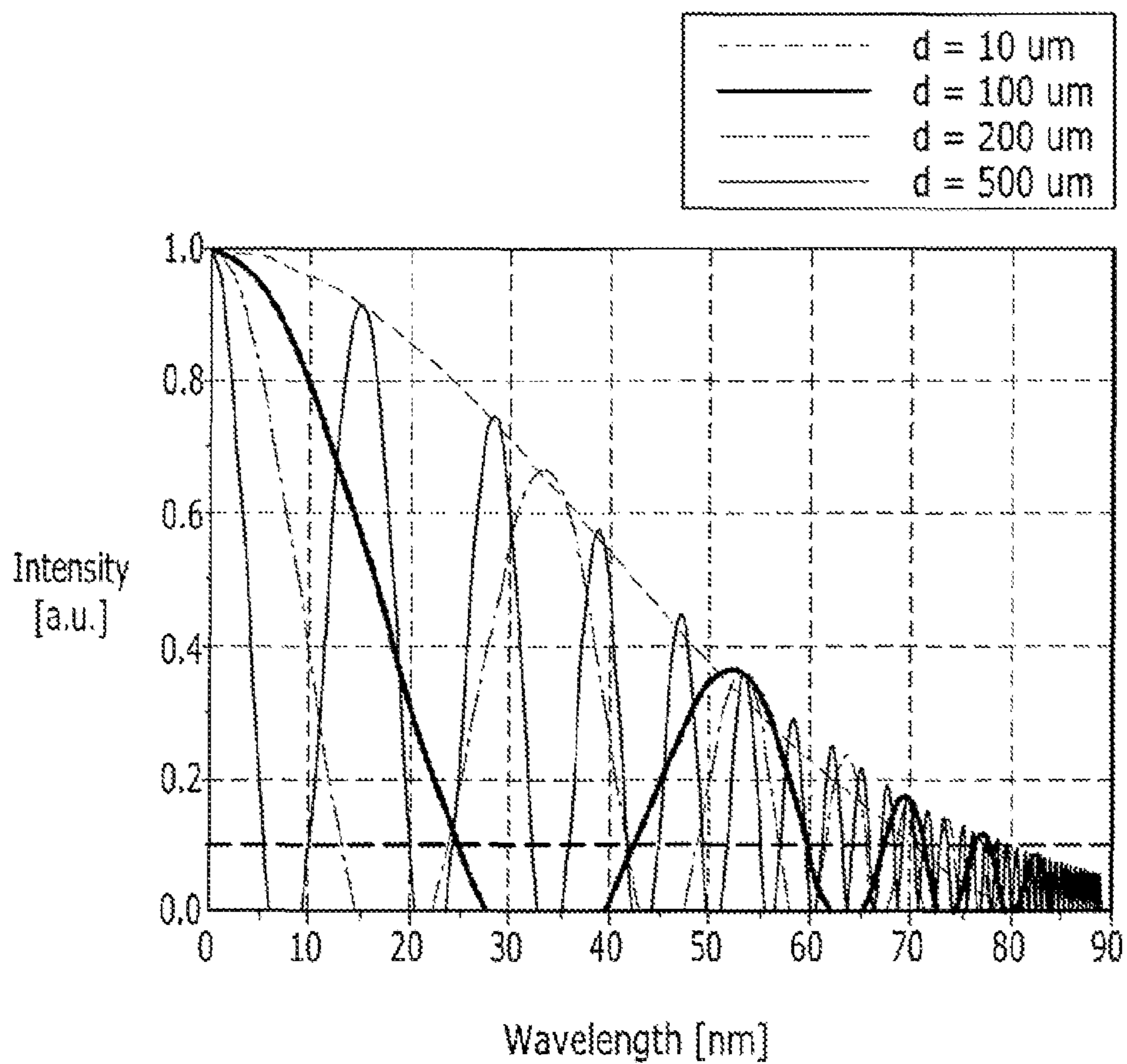




FIG. 28

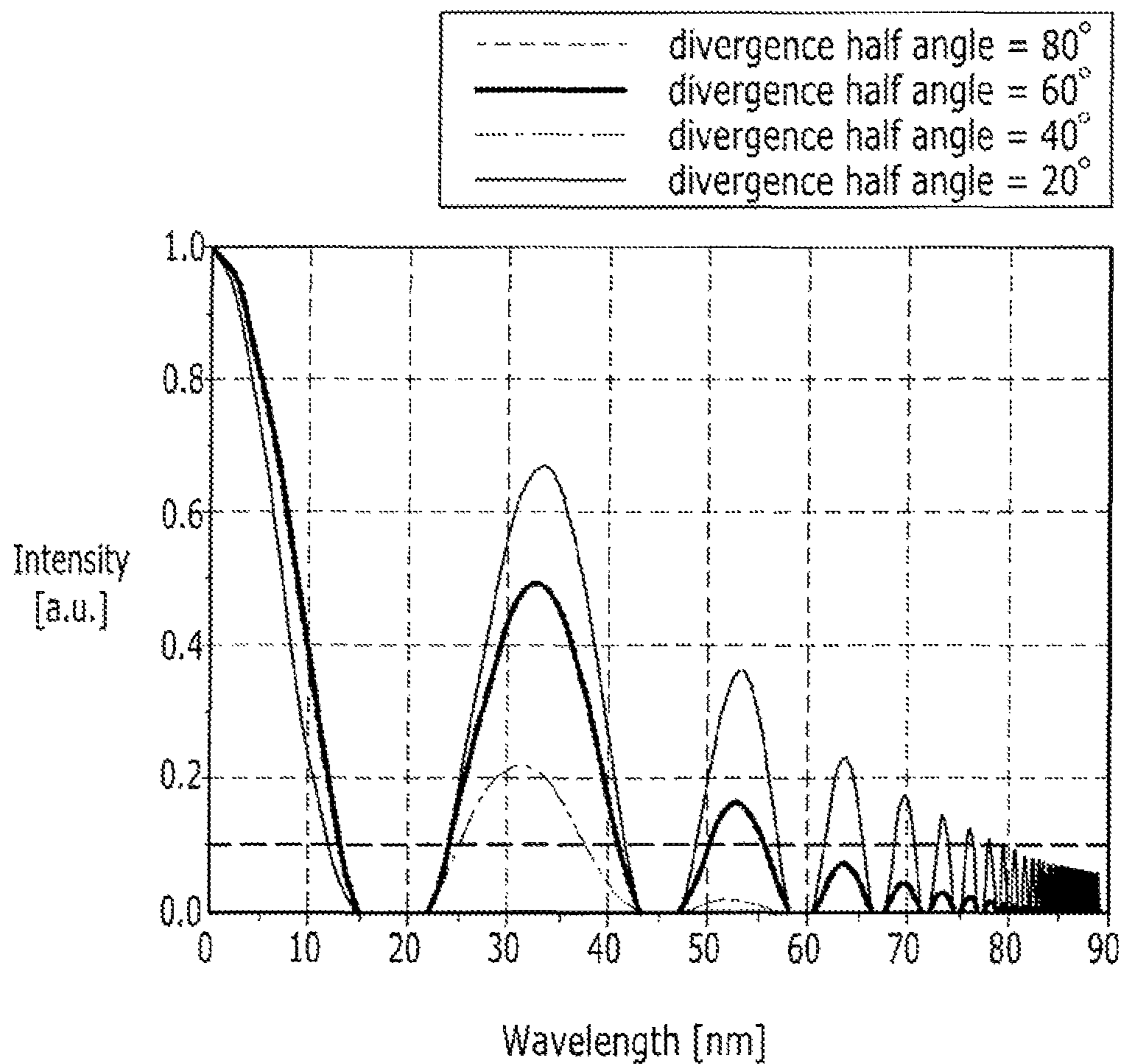


FIG. 29

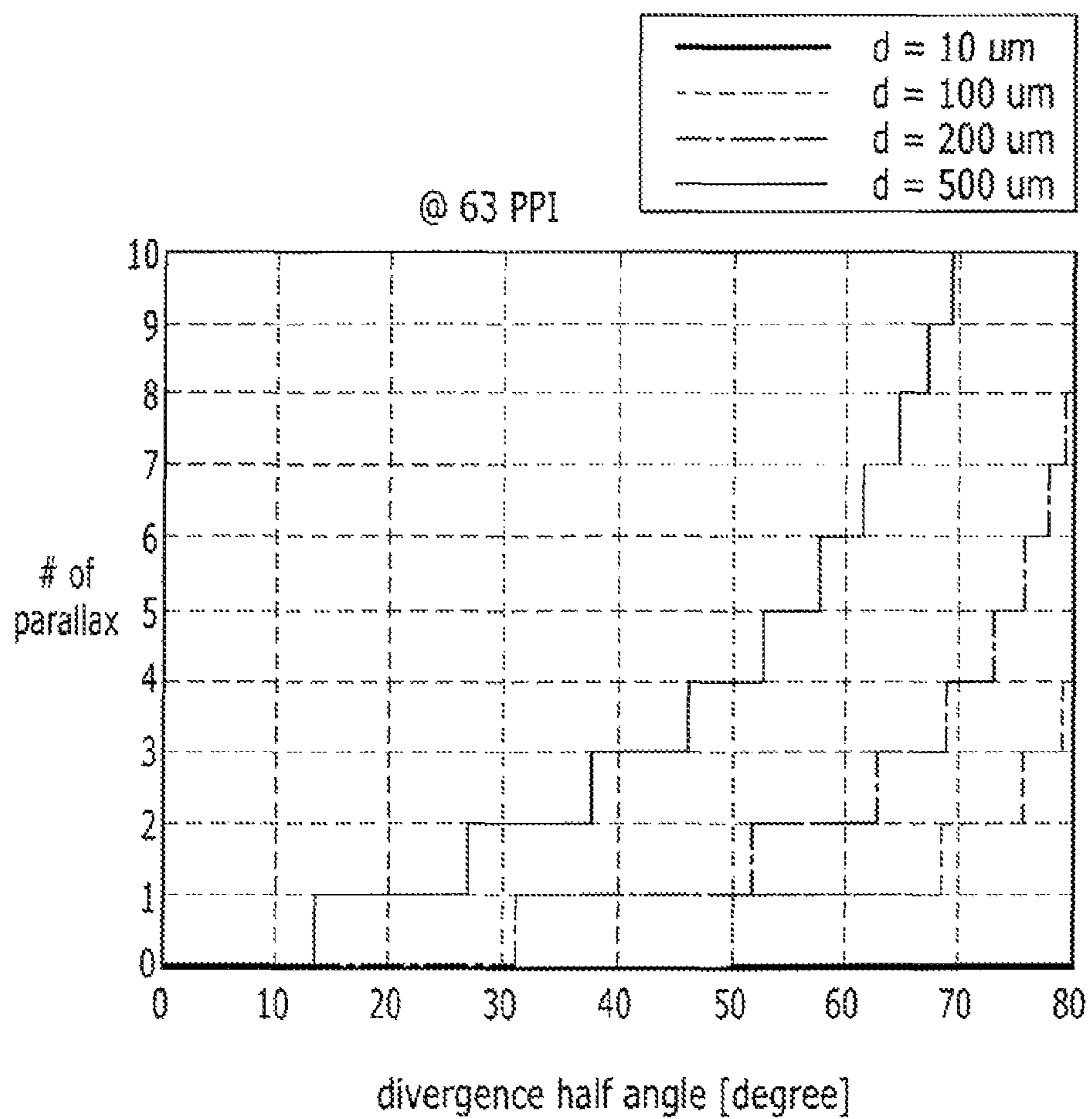


FIG. 30

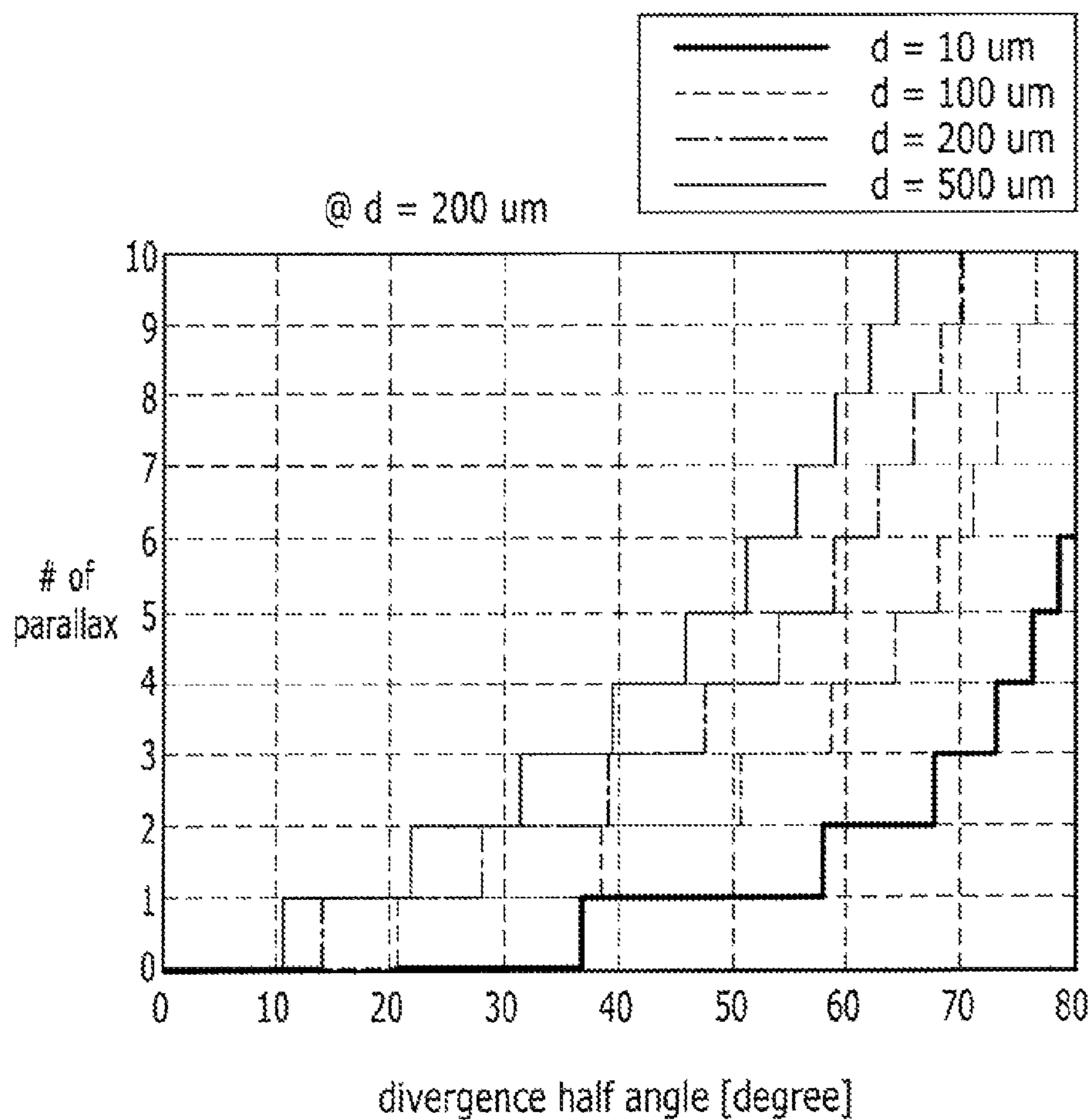
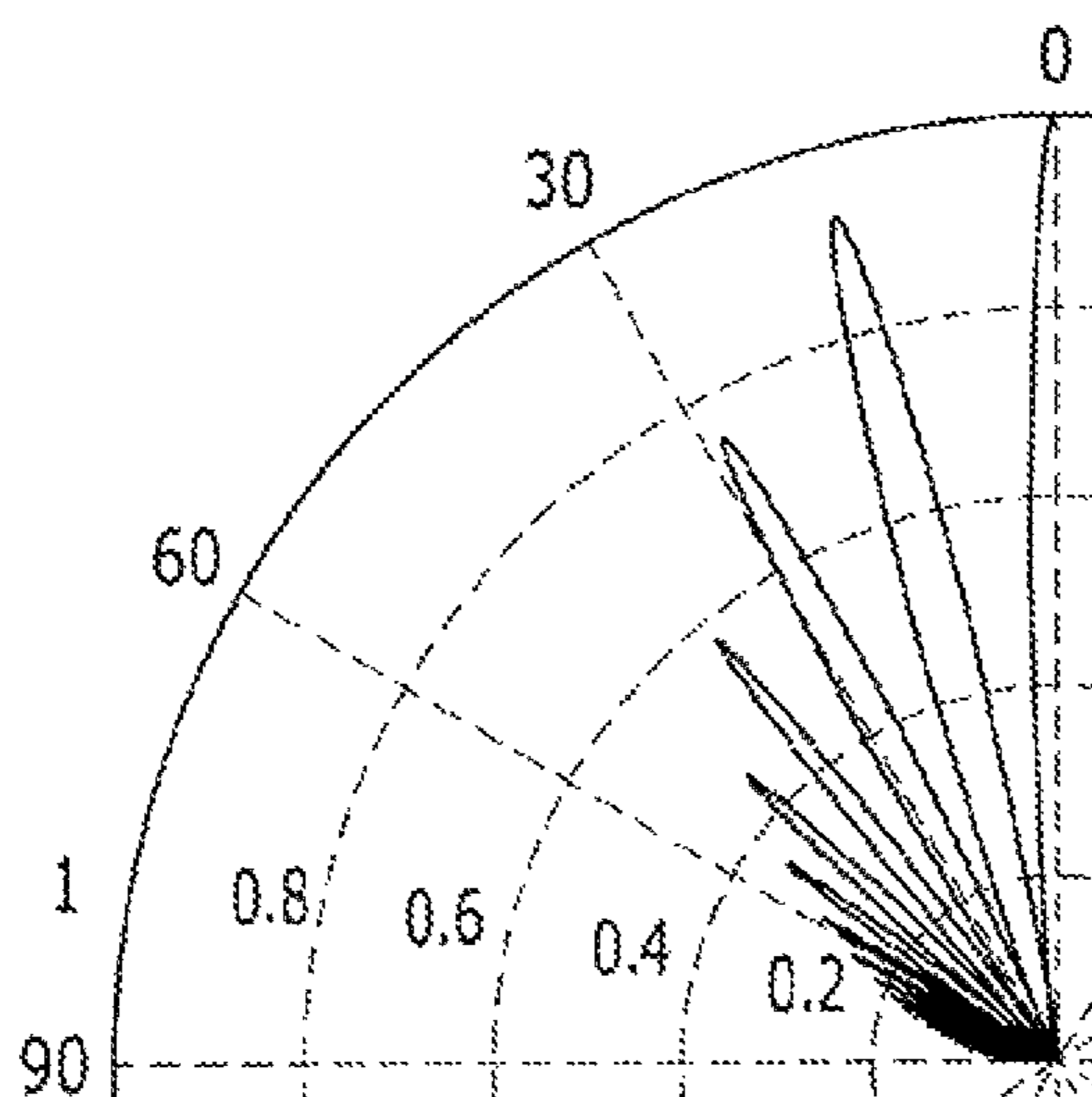


FIG. 31

- Divergence angle  $\sim 80^\circ$
- Distance(LC to QD layer)  $\sim 500 \text{ um}$



- Divergence angle  $\sim 55^\circ$
- Distance(LC to QD layer)  $\sim 100 \text{ um}$

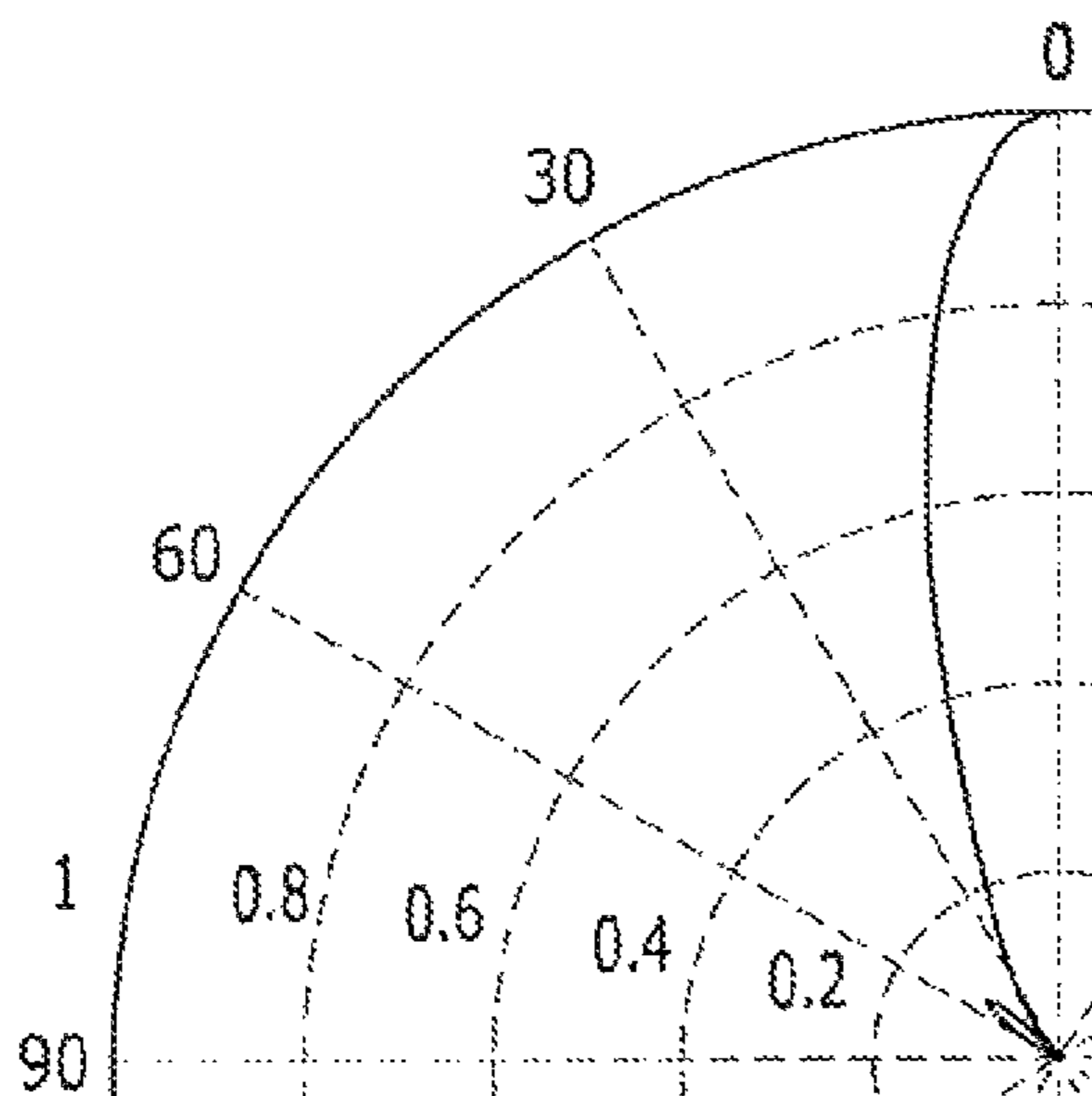


FIG. 32

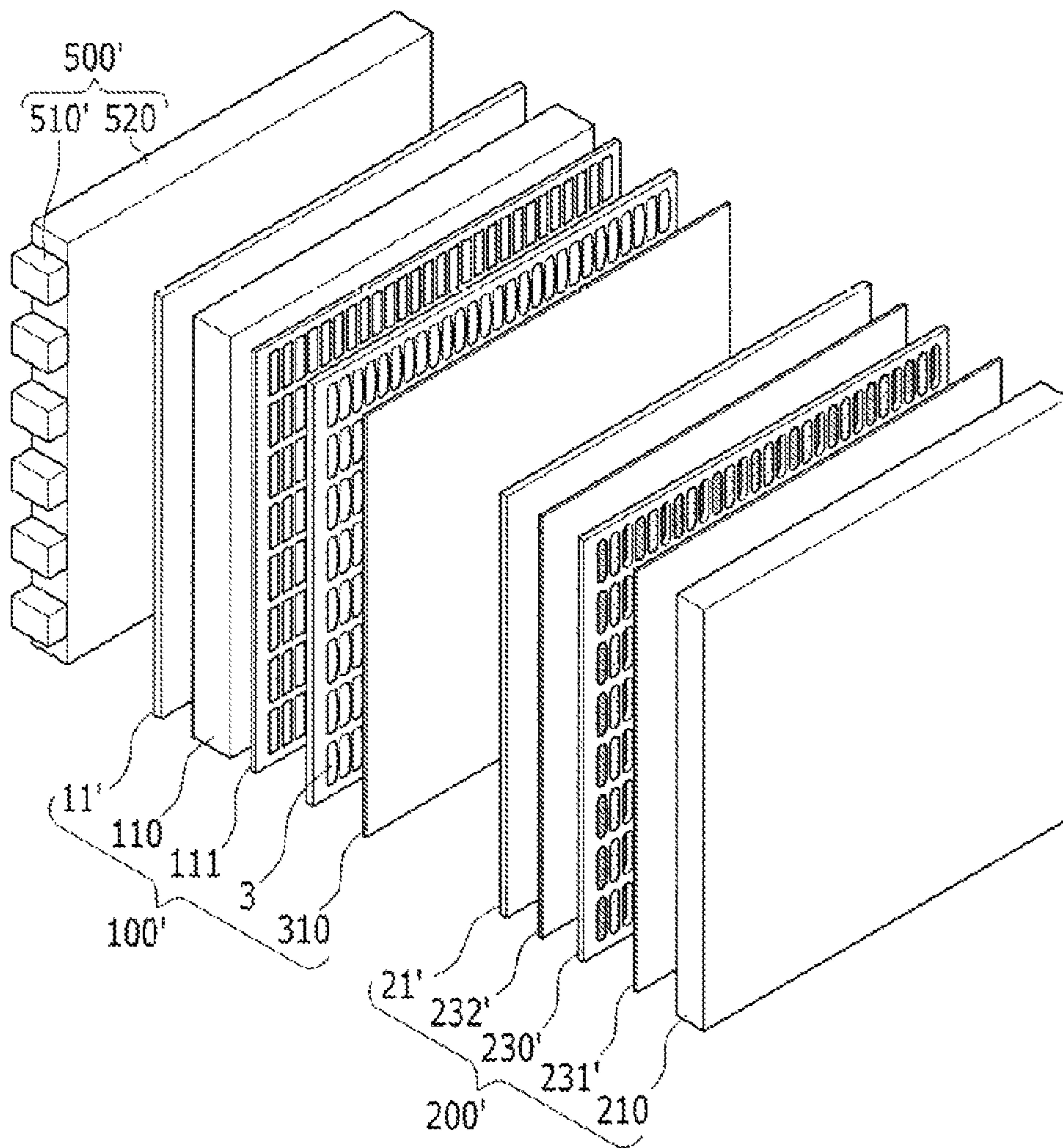




FIG. 33

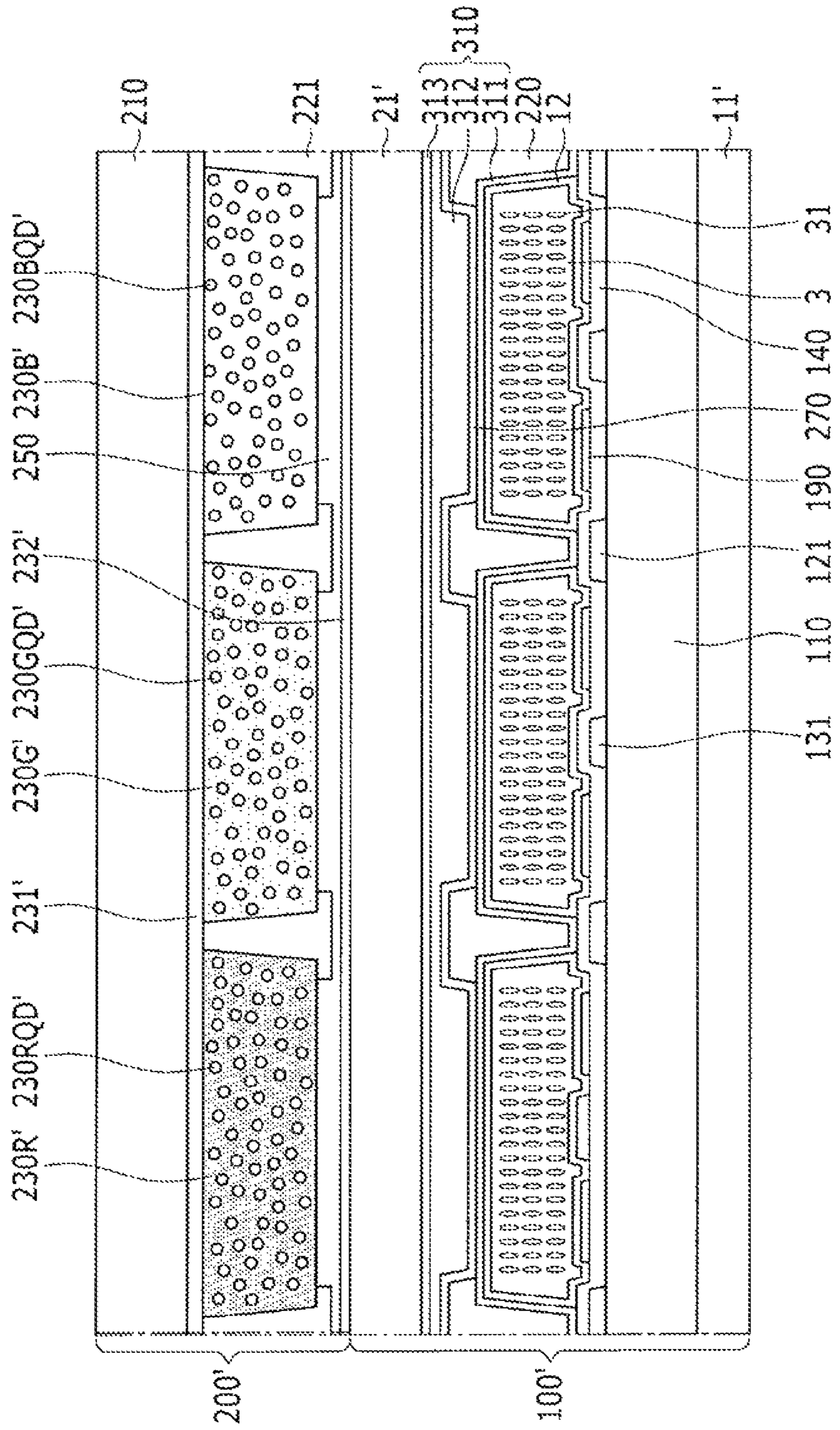


FIG. 34

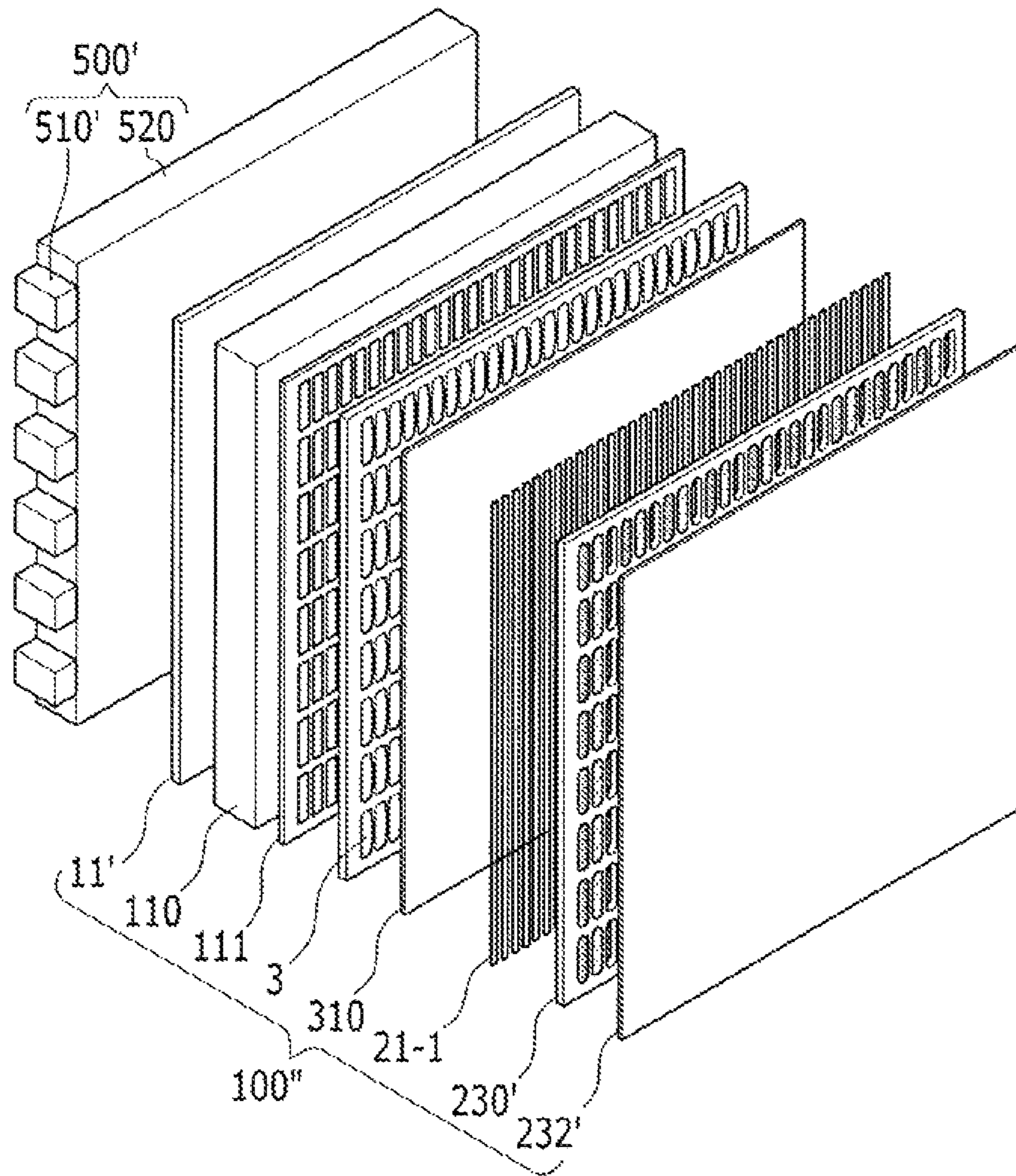
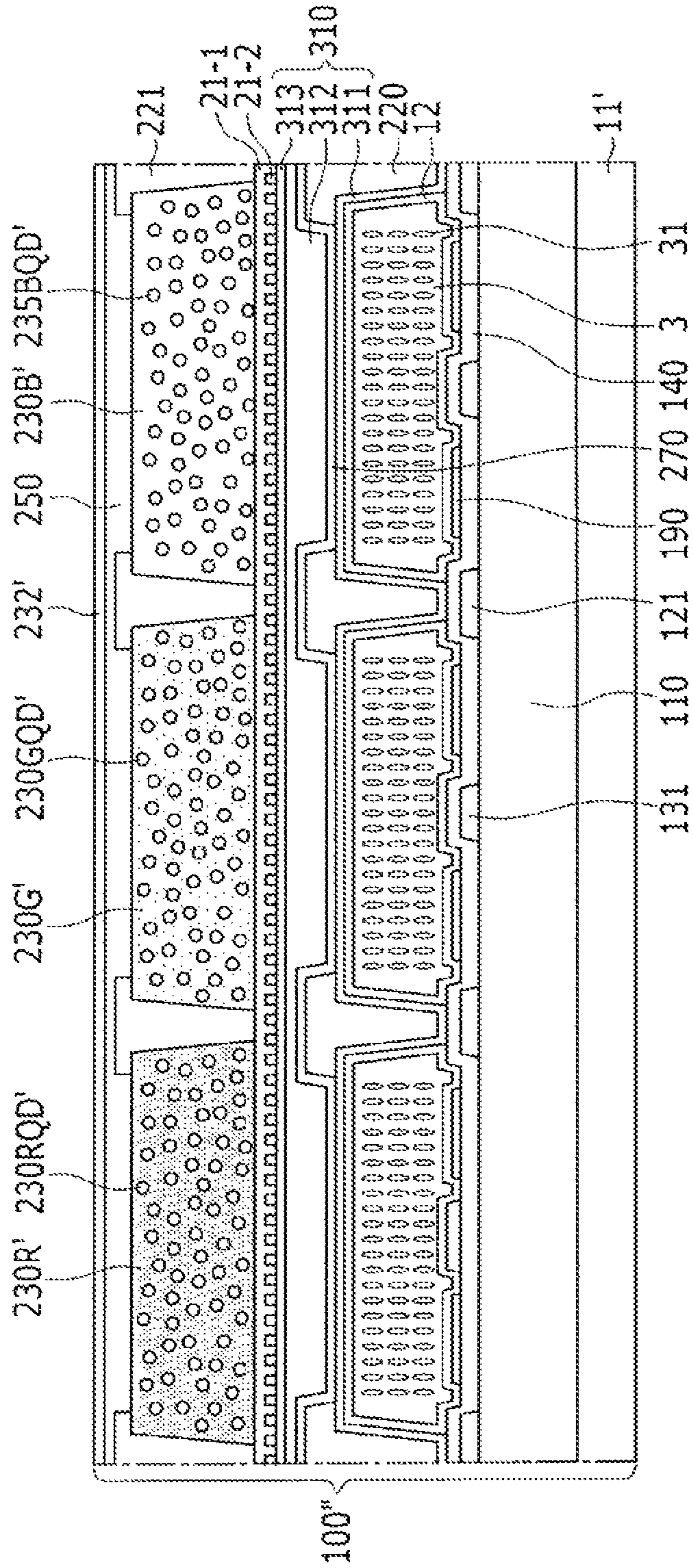




FIG. 35





## LIQUID CRYSTAL DISPLAY AND MANUFACTURING METHOD THEREOF

### CROSS-REFERENCE TO RELATED APPLICATION

This application is a divisional of U.S. application Ser. No. 13/645,207, filed on Oct. 4, 2012 in the U.S. Patent and Trademark Office, which in turn claims priority under 35 U.S.C. § 119 from, and the benefit of, Korean Patent Application No. 10-2012-0026772, filed in the Korean Intellectual Property Office on Mar. 15, 2012, the contents of which are herein incorporated by reference in their entirety.

### TECHNICAL FIELD

The present disclosure relates to a liquid crystal display and a manufacturing method thereof.

### DISCUSSION OF THE RELATED ART

A liquid crystal display, which is one of the most common types of flat panel displays currently in use, includes two sheets of panels with field generating electrodes such as a pixel electrode, a common electrode, and the like. A liquid crystal layer is interposed therebetween.

The liquid crystal display generates an electric field in the liquid crystal layer by applying voltage to the field generating electrodes. The direction of liquid crystal molecules of the liquid crystal layer is determined by the generated electric field. Thus, polarization of incident light is controlled so as to display images.

To display a color in the liquid crystal display, a color filter is used and a structure including a luminescent material as a material of the color filter has been developed. In the case where the luminescent material is included in the color filter, a liquid crystal display having a wide viewing angle may be easily manufactured and power consumption may be improved, but display characteristics due to an adjacent pixel and the parallax of a viewed object (i.e., the difference in the apparent position of an object viewed along two different lines of sight) can be deteriorated.

### SUMMARY

Exemplary embodiments of the present invention provide a liquid crystal display such that display characteristics due to parallax are not deteriorated and the display has a wide viewing angle. A manufacturing method thereof is also provided.

An exemplary embodiment of the present invention provides a liquid crystal display. A backlight unit includes a light source. A display panel includes a liquid crystal layer disposed in a microcavity. A color filter is configured to change a wavelength of light supplied from the light source to display a color. A lower polarizer is located between the liquid crystal layer and the backlight unit. An upper polarizer is located between the liquid crystal layer and the color filter.

The display panel may include an upper panel and a lower panel. The lower panel may include the liquid crystal layer and the lower polarizer. The upper panel may include the color filter.

The upper polarizer may be included in the upper panel or the lower panel, and the upper panel may be disposed above the upper polarizer and the lower panel may be disposed below the upper polarizer.

The upper and lower polarizers may include a polarization element configured to generate polarization and a tri-acetylcellulose (TAC) layer for ensuring durability.

The microcavity may be shaped by a support layer. An alignment layer may be formed on the support layer. The liquid crystal layer may be aligned by the alignment layer.

A common electrode and a patterned insulating layer may be over the support layer, and a liquid crystal injection hole may be formed on the patterned insulating layer, the common electrode, and the support layer.

The color filter may include quantum dot particles configured to convert light supplied from the light source.

The light source may be a blue light source.

A color filter may be a transparent color filter for displaying the color blue, and the transparent color filter may include scattering particles.

A blue light transmitting layer may be located between the liquid crystal layer and the color filter and may be configured to transmit only light in a blue wavelength band.

A blue light blocking layer may be configured to block light in a blue wavelength band and may be located at a side of the color filter opposite the blue light transmitting layer.

The transparent color filter may not have the blue light blocking layer formed thereon.

The light source may be an ultraviolet rays light source.

An ultraviolet rays transmitting layer may be located between the liquid crystal layer and the color filter and may be configured to transmit only ultraviolet rays.

An ultraviolet rays blocking layer may be configured to block the ultraviolet rays and may be located at a side of the color filter opposite the ultraviolet rays transmitting layer.

The display panel may be formed by one display panel.

The upper polarizer may include metal wirings arranged with an interval of 100 nm or less.

An exemplary embodiment of the present invention provides a method of manufacturing a liquid crystal display, including: forming a thin film transistor on a substrate; forming a pixel electrode on the thin film transistor, forming a sacrificial layer on the pixel electrode, forming a support layer on the sacrificial layer, forming a microcavity including a liquid crystal injection hole by removing the sacrificial layer; injecting a liquid crystal material into microcavity, forming a coating layer on the support layer so as to cover the liquid crystal injection hole, and forming a color filter including quantum dot particles for converting light supplied from a light source.

The method of manufacturing a liquid crystal display may further include forming an alignment layer on an outer wall of the microcavity before the liquid crystal material is injected into the microcavity.

The method of manufacturing a liquid crystal display may further include forming a common electrode between the support layer and the coating layer, in which the liquid crystal injection hole may also be formed in the common electrode.

According to an exemplary embodiment of the present invention a liquid crystal display includes a backlight unit, a color filter and a liquid crystal layer formed in a microcavity located between the backlight unit and the color filter. The color filter includes quantum dot particles configured to refract and disperse light from the backlight unit. A distance between the color filter and the liquid crystal layer is sized to minimize display deterioration due to parallax.

### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an exploded perspective view of a liquid crystal display according to an exemplary embodiment of the present invention.



FIG. 2 is a cross-sectional view of the liquid crystal display according to the exemplary embodiment of FIG. 1.

FIG. 3 is a cross-sectional view of a lower panel in the liquid crystal display according to the exemplary embodiment of FIG. 1.

FIGS. 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 and 14 are diagrams illustrating in sequence a manufacturing method of the lower panel according to the exemplary embodiment of FIG. 3.

FIG. 15 is a cross-sectional view of an upper panel in the liquid crystal display according to the exemplary embodiment of FIG. 1.

FIGS. 16, 17, 18 and 19 are diagrams illustrating in sequence a manufacturing method of the upper panel according to the exemplary embodiment of FIG. 15.

FIGS. 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30 and 31 are graphs showing characteristics of the liquid crystal display according to exemplary embodiments of the present invention.

FIG. 32 is an exploded perspective view of a liquid crystal display according to an exemplary embodiment of the present invention.

FIG. 33 is a cross-sectional view of the liquid crystal display according to the exemplary embodiment of FIG. 32.

FIG. 34 is an exploded perspective view of a liquid crystal display according to an exemplary embodiment of the present invention.

FIG. 35 is a cross-sectional view of the liquid crystal display according to the exemplary embodiment of FIG. 34.

#### DETAILED DESCRIPTION

The present invention will be described more fully hereinafter with reference to the accompanying drawings, in which exemplary embodiments of the invention are shown. As those skilled in the art would realize, the described embodiments may be modified in various different ways, all without departing from the spirit or scope of the present invention.

In the drawings, the thickness of layers, films, panels, regions, etc., may be exaggerated for clarity. Like reference numerals designate like elements throughout the specification. It will be understood that when an element such as a layer, film, region, or substrate is referred to as being "on" another element, it can be directly on the other element or intervening elements may also be present.

Hereinafter, a liquid crystal display according to an exemplary embodiment of the present invention will be described in detail with reference to FIGS. 1 and 2.

FIG. 1 is an exploded perspective view of a liquid crystal display according to an exemplary embodiment of the present invention and FIG. 2 is a cross-sectional view of the liquid crystal display according to the exemplary embodiment of FIG. 1.

As shown in FIG. 1, the liquid crystal display according to the exemplary embodiment of the present invention includes a lower panel 100, an upper panel 200, and a backlight unit 500.

The backlight unit 500 includes a blue light source 510 and a light guide plate 520. The lower panel 100 disposed thereon includes a lower polarizer 11, a lower substrate 110, a wiring layer 111, a liquid crystal layer 3 formed in a microcavity, an upper insulating layer 310, and an upper polarizer 21. The upper panel 200 disposed thereon includes an upper substrate 210, a blue light blocking layer 231, a color filter 230, and a blue light transmitting layer 232.

First, the lower panel 100 will be described with reference to FIGS. 1, 2 and 3.

FIG. 3 is a cross-sectional view of a lower panel in the liquid crystal display according to the exemplary embodiment of FIG. 1.

Referring to FIGS. 1 to 3, a wiring layer 111 including a thin film transistor (not shown) and the like is formed on a substrate 110 made of transparent glass, plastic, or the like. The wiring layer 111 includes a gate line 121, a storage voltage line 131, a gate insulating layer 140, a data line (not shown), a passivation layer (not shown) and a pixel electrode 190, and the thin film transistor is connected to the gate line 121 and the data line. Structures of the pixel electrode 190, the gate line 121, and the data line formed on the wiring layer 111 may vary according to an exemplary embodiment.

The gate line 121 and the storage voltage line 131 are disposed below the gate insulating layer 140 and are electrically separated from each other. The data line crosses the gate line 121 and the storage voltage line 131 and is insulated therefrom. The gate electrode on the gate line 121 and the source electrode on the data line provide a control terminal and an input terminal of the thin film transistor, respectively. Further, an output terminal (drain electrode) of the thin film transistor is connected with the pixel electrode 190, and the pixel electrode 190 is insulated from the gate line 121, the storage voltage line 131 and the data line.

A support layer 311 is disposed on the pixel electrode 190 and the passivation layer. The support layer 311 serves to support itself so that an inner portion of the support layer 311, that is, an upper space, hereinafter referred to as a microcavity (see microcavity 305 of FIG. 11) of the pixel electrode 190 and the passivation layer may be formed. A cross section of the support layer 311 according to the exemplary embodiment may have a trapezoid shape, and have a liquid crystal injection hole 335 (seen in FIG. 14) on one side thereof in order to inject a liquid crystal into the microcavity 305. The support layer 311 may include an inorganic insulating material such as silicon nitride (SiNx) and the like.

Further, to arrange liquid crystal molecules injected in the microcavity 305, an alignment layer 12 is formed at the inside of the support layer 311, that is, at the upper portion of the pixel electrode 190 and the passivation layer. The alignment layer 12 made of at least one of generally used materials such as polyamic acid, polysiloxane, or polyimide, or the like, as a liquid crystal alignment layer may be formed.

The liquid crystal layer 3 is formed under the alignment layer 12 of the microcavity 305, and the liquid crystal molecules 31 are initially aligned by the alignment layer 12. A thickness of the liquid crystal layer 3 may be about 5 to 6  $\mu\text{m}$ .

A light blocking member 220 is formed between the adjacent support layers 311. The light blocking member 220 includes a material which does not transmit light and has an opening, and the opening that corresponds with the microcavity 305.

A common electrode 270 is formed on the support layer 311 and the light blocking member 220. The common electrode 270 and the pixel electrode 190 are made of a transparent conductive material such as ITO or IZO and serve to control an alignment direction of the liquid crystal molecules 31 by generating an electric field.

A flattening layer 312 is formed on the common electrode 270. The flattening layer 312, as a layer for removing a step generated on the common electrode 270 due to the light blocking member 220, may include an organic material. The flattening layer 312 may alternatively be disposed below the common electrode 270 or may be omitted.



## 5

A patterned insulating layer **313** is formed on the flattening layer **312**. The patterned insulating layer **313** may include an inorganic insulating material such as silicon nitride (SiNx). The flattening layer **312** and the patterned insulating layer **313** are patterned together with the support layer **311** and combined to form upper insulating layer **310** and provide a liquid crystal injection hole **335**. In an alternative exemplary embodiment the patterned insulating layer **313** may be omitted.

In FIG. 1, the support layer **311**, the flattening layer **312**, and the patterned insulating layer **313** are shown as one upper insulating layer **310**. As shown in FIG. 2, the common electrode **270** is disposed between the support layer **311** and the flattening layer **312**. However, as long as the common electrode **270** is an upper portion of the support layer **311**, the common electrode **270** may also be disposed above the flattening layer **312** or the patterned insulating layer **313**.

An upper polarizer **21** is disposed above the patterned insulating layer **313**. The upper polarizer **21** may be thinly formed and may have a thickness of 150 to 200  $\mu\text{m}$ . The upper polarizer **21** includes a polarization element generating polarization and a tri-acetyl-cellulose (TAC) layer for ensuring durability.

A lower polarizer **11** is attached to the rear surface of the substrate **110**. The lower polarizer **11** may not be thinly formed and includes a polarization element generating polarization and a tri-acetyl-cellulose (TAC) layer for ensuring durability. However, the lower polarizer **11** may be formed between the substrate **110** and the wiring layer **111** and may also be formed at other positions.

Hereinafter, a manufacturing method of the lower panel **100** will be described in detail with reference to FIGS. 4 to 14.

FIGS. 4 to 14 are diagrams illustrating in sequence a manufacturing method of the lower panel according to the exemplary embodiment of FIG. 3.

First, as shown in FIG. 4, the wiring layer **111** shown in FIG. 1, including a thin film transistor and the like, is formed on a lower substrate **110**.

The lower substrate is made of transparent glass, plastic, or the like, the gate line **121**, the storage voltage line **131**, the gate insulating layer **140**, the data line (not shown), the passivation layer (not shown), and the pixel electrode **190** are formed on the wiring layer **111**, and the thin film transistor is connected to the gate line **121** and the data line.

In FIG. 4, it is simply described that the wiring layer **111** is formed on the lower substrate **110**, but actually, a plurality of processes are included.

For example, the plurality of processes are as follows.

On the lower substrate **110**, the gate line **121** and the storage voltage line **131** are formed and thereafter, the gate insulating layer **140** covering the lower substrate **110**, the gate line **121**, and the storage voltage line **131** are formed.

On the gate insulating layer **140**, the data line is formed in a direction crossing the gate line **121** and the storage voltage line **131**, and a drain electrode, which is an output terminal of the thin film transistor, is also formed. Thereafter, a passivation layer covering the data line and the drain electrode is formed and a contact hole which exposes a part of the drain electrode is formed in the passivation layer.

The pixel electrode **190** is formed on the passivation layer and is electrically connected with the drain electrode through the contact hole of the passivation layer.

In FIG. 4, as described above, structures of the pixel electrode **190**, the gate line **121**, and the data line may be varied according to an exemplary embodiment.

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Thereafter, referring to FIG. 5, a sacrificial layer **300** is formed in a region where the microcavity is to be formed. The sacrificial layer may be made of a photoresist material and be formed by being etched in accordance with the position, the size, and the shape of the microcavity to be formed. Since the microcavity is positioned where the liquid crystal layer **3** is to be formed, the microcavity corresponds to the pixel area.

Thereafter, referring to FIG. 6, the support layer **311**, which covers the sacrificial layer **300** and the exposed wiring layer **111**, is formed. The support layer **311** may be made of an inorganic insulating material such as silicon nitride (SiNx) and may be formed to have a thickness of about 2000  $\text{\AA}$ . Further, the support layer **311** is formed so as to cover the entire sacrificial layer **300** along the surface of the sacrificial layer **300**. As shown in FIG. 6, a cross section of the sacrificial layer **300** and the support layer **311** may form a trapezoid.

Next, as shown in FIG. 7, the light blocking member **220** is formed between the adjacent vertical portions of the support layers **311**. The light blocking member **220** may be of a material which does not transmit light and has an opening. The opening of the light blocking member **220** corresponds to the sacrificial layer **300** or the microcavity **305**.

Thereafter, as shown in FIG. 8, the common electrode **270** covering the support layer **311** and the light blocking member **220** is formed. The common electrode **270** is made of a transparent conductive material such as ITO or IZO much like the pixel electrode **190** and serves to control an alignment direction of the liquid crystal molecules **31** by generating an electric field together with the pixel electrode **190**.

Next, as shown in FIG. 9, a lower flattening layer **312** is formed. The lower flattening layer **312**, serves as a layer for removing a step generated on the common electrode **270** due to the light blocking member **220**, and may be of an organic material.

Thereafter, as shown in FIG. 10, a patterned insulating layer **313** is formed on the lower flattening layer **312**. The patterned insulating layer **313** forms a liquid crystal injection hole (see **335** of FIG. 14) by patterning a silicon nitride (SiNx) layer laminated together with the lower flattening layer **312** and the support layer **311** after depositing an inorganic insulating material such as silicon nitride (SiNx) and the like at about 2000  $\text{\AA}$ .

Next, as shown in FIG. 11, a microcavity **305** supported by the support layer **311** is formed by supplying an etchant through the liquid crystal injection hole to remove the sacrificial layer **300** disposed in the support layer **311**. The process described above may be performed through a wet etching method in which the lower panel **100** manufactured in FIGS. 1 to 10 is soaked in an etchant such as a photoresist (PR) stripper for a predetermined time.

Thereafter, as shown in FIG. 12, an alignment layer **12** is formed in the microcavity **305**. In a method of forming the alignment layer **12** in the microcavity **305**, when a liquid aligning agent is fully filled in the microcavity **305** through the liquid crystal injection hole by an Inkjet or spin coating method and then cured at a temperature of about 210 degrees for about 1 hour, a solvent included in the aligning agent is volatilized and only polyimide (PI) is cured on the inner surface of the support layer **311** to form the alignment layer **12**. The rest of the aligning agent is discharged and removed through the liquid crystal injection hole.

Next, as shown in FIG. 13, the liquid crystal layer **3** is filled in the microcavity **305** utilizing the alignment layer **12** as a wall. In a method of filling the liquid crystal layer **3** in



the microcavity **305**, liquid crystal material is supplied by a spin coating or inkjet method and the liquid crystal material is injected into the microcavity **305** by surface energy of silicon nitride (SiN<sub>x</sub>) constituting the support layer **311** and the patterned insulating layer **313** and interaction of a capillary force generated in the liquid crystal injection hole. The injected liquid crystal molecules **31** are aligned in a predetermined direction by the alignment layer **12**. The thickness of the injected liquid crystal layer **3** may be formed to be about 5 to 6 μm.

Thereafter, as shown in FIG. **14**, to block the liquid crystal injection hole **335** from the outside, a coating layer **340** is formed on the lower panel **100** through ultraviolet slit coating. The coating layer **340** is formed by a method of irradiating ultraviolet rays while slit-coating a transparent organic material and as a result, the liquid crystal injection hole **335** is blocked. The coating layer **340** shown in FIG. **14** may not be needed if a separate structure is formed which blocks the liquid crystal injection hole **335** from the outside.

Next, referring back to FIG. **3**, the upper polarizer **21** is formed above the coating layer **340**. The upper polarizer **21** may be thinly formed and have a thickness of 100 to 200 μm. The upper polarizer **21** includes a polarization element generating polarization and a tri-acetyl-cellulose (TAC) layer for ensuring durability.

Further, as shown in FIG. **1**, the lower polarizer **11** is attached to the rear surface of the substrate **110**. The lower polarizer **11** may include a polarization element generating polarization and a tri-acetyl-cellulose (TAC) layer for ensuring durability.

The lower panel **100** is completed by the method as described above. Since all of the liquid crystal layer **3**, the common electrode **270**, the alignment layer **12**, the pixel electrode **190**, the lower polarizer **11**, and the upper polarizer **21** are included in the completed lower panel **100**, all basic operations as the liquid crystal display can be performed by the lower panel **100**. However, since the lower panel **100** does not include a color filter **230** capable of displaying a color, the color cannot be displayed and thus hereinafter, the lower panel **100** is also referred to as a black and white liquid crystal display panel.

The upper panel **200** having the color filter **230** will now be described in detail with reference to FIGS. **1**, **2**, and **15**.

FIG. **15** is a cross-sectional view of an upper panel in the liquid crystal display according to the exemplary embodiment of FIG. **1**.

An upper panel **200** is disposed on the upper polarizer **21**.

Referring to FIGS. **1** and **2**, in the upper panel **200**, the blue light blocking layer **231** is formed below the upper substrate **210** made of transparent glass, plastic, or the like. The blue light blocking layer **231** is not formed only in a pixel area displaying blue because an opening **231-1** is included and is formed in pixel areas displaying red and green. The blue light blocking layer **231** may be formed by alternately laminating at least two layers having different refractive indexes, such that wavelengths other than a blue wavelength band are transmitted while the blue wavelength band being blocked. The blocked blue wavelength is reflected and thus a light recycle may also be performed. Since the blue light blocking layer **231** serves to block light emitted from a blue light source, such as blue light source **510** of FIG. **1**, from being directly emitted outside, the blue light blocking layer **231** is not formed only in the pixel area displaying blue and is formed in pixel areas displaying red and green.

In the exemplary embodiment of the present invention, since blue light is used as a light source, the opening **231-1**

is formed in the pixel area displaying blue. However, a red or green light source may be used according to an exemplary embodiment, and in this case, the opening is formed in the pixel area displaying the corresponding color.

An upper light blocking member **221** is formed below the upper substrate **210** and below the blue light blocking layer **231**. The upper light blocking member **221** also has an opening, and a color filter corresponding to a color displayed in the corresponding pixel is formed.

First, a red color filter **230R** is formed in a red pixel, a green color filter **230G** is formed in a green pixel, and a transparent color filter **230T** is formed in a blue pixel. The reason for using the transparent color filter **230T** in the blue pixel is because a blue light source is used as the light source **510** of the backlight **500** in the exemplary embodiments of FIGS. **1** and **2**.

The red color filter **230R** may include red quantum dot (QD) particles **230RQD**, and converts light having a wavelength supplied by the blue light source **510** into red.

Further, the green color filter **230G** may include green quantum dot (QD) particles **230GQD** and converts light having a wavelength supplied by the blue light source **510** into green.

In addition, the transparent color filter **230T** includes scattering particles **235** which do not convert a wavelength of light having a wavelength supplied by the blue light source **510** but merely changes the direction of light. The scattering particles **235** may be particles such as TiO<sub>2</sub> and the like, and the sizes thereof may correspond with the sizes of the red quantum dot (QD) particles **230RQD** or the green quantum dot (QD) particles **230GQD**.

In the exemplary embodiment of the present invention, since light supplied by the light source **510** of the backlight is scattered in the red quantum dot (QD) particles **230RQD**, the green quantum dot (QD) particles **230GQD**, and the scattering particles **235** and then emitted outside to display an image, the direction of light emitted outside is wide and grays of the light are not changed according to position, such that the light may have a wide viewing angle.

In the color filter **230**, pixels having the same color may be disposed in a column direction elongated along a column of the pixel electrode **190** shown in FIG. **2**, and are not limited to three primary colors of red, green, and blue according to an exemplary embodiment and may also display one of cyan, magenta, yellow, and white based colors.

As seen in FIG. **2**, an upper flattening layer **250** is formed below the upper light blocking member **221**, the red color filter **230R**, the green color filter **230G**, and the transparent color filter **230T**. The upper flattening layer **250** may be made of an organic material and may also be omitted in an exemplary embodiment.

A blue light transmitting layer **232** is formed below the upper flattening layer **250** and formed even in the pixel displaying blue unlike the blue light blocking layer **231**. That is, the blue light transmitting layer **232** is formed in the entire area of the upper panel **200**. The blue light transmitting layer **232** may be formed by alternately laminating at least two layers having different refractive indexes, and transmits only the blue wavelength band and blocks other wavelength bands. The light of the blocked wavelength band is reflected and thus a light recycle may be performed. The blue light transmitting layer **232** transmits blue light inputted from the blue light source **510** as it is, and is formed such that other unnecessary wavelengths are blocked.

The lower panel **100** is disposed below the blue light transmitting layer **232**, and the upper polarizer **21** and the blue light transmitting layer **232** of the upper panel **100** are



attached to each other. They may be directly attached to each other or may be adhered to each other through a separate adhesive.

A manufacturing method of the upper panel **200** will now be described with reference to FIGS. **16** to **19**.

FIGS. **16** to **19** are diagrams illustrating a manufacturing method of the upper panel according to the exemplary embodiment of FIG. **15** in sequence.

As shown in FIG. **16**, the blue light blocking layer **231** is formed on the upper substrate **210** made of transparent glass, plastic, or the like. The blue light blocking layer **231** has an opening **231-1** and the opening **231-1** is formed only in a pixel area displaying blue. That is, the blue light blocking layer **231** is formed in pixel areas displaying red and green. The blue light blocking layer **231** may be a film formed by alternately laminating at least two layers having different refractive indexes, and is attached on the lower surface of the upper substrate **210** to be formed. The blue light blocking layer **231** transmits wavelengths other than for the blue wavelength band and blocks the blue wavelength band. The blocked blue wavelength is reflected to perform a light recycle.

Thereafter, as shown in FIG. **17**, the respective color filters **230** are formed to be below the upper substrate **210** exposed by the blue light blocking layer **231** and the opening **231-1**. The manufacturing process of the color filter **230** forms three separate color filters.

First, a method of forming the red color filter **230R** in a red pixel will be described.

The red color filter **230R** is formed by laminating a material including a plurality of red quantum dot (QD) particles **230RQD** which change blue light to red light in a transparent organic material or a transparent photoresist and leaving the material only in the red pixel area to perform patterning.

Thereafter, the green color filter **230G** is formed by laminating a material including a plurality of green quantum dot (QD) particles **230GQD** which change blue light to green light in the transparent organic material or the transparent photoresist and leave the material only in the green pixel area to perform patterning.

Next, the transparent color filter **230T** is formed by laminating a material including the scattering particles **235** which disperse incident light in the transparent organic material or the transparent photoresist and leave the material only in the blue pixel area to perform patterning. The scattering particles **235** are sufficient so long as the scattering particles **235** are particles dispersing the light, and, as an example, TiO<sub>2</sub> particles are included.

Thereafter, as shown in FIG. **18**, the upper light blocking member **221** is formed between the adjacent color filters **230**. The upper light blocking member **221** has an opening and the color filters **230** are disposed at the respective openings. The upper light blocking member **221** includes a material which does not transmit light. As shown in FIG. **18**, the upper flattening layer **250** is formed on the upper light blocking member **221**, the red color filter **230R**, the green color filter **230G**, and the transparent color filter **230T**. The upper flattening layer **250** may be made of an organic material.

Next, as shown in FIG. **19**, the blue light transmitting layer **232** is formed on the upper flattening layer **250**. The blue light transmitting layer **232** may also be a film formed by alternately laminating at least two layers having different refractive indexes. The blue light transmitting layer **232** is formed even in the pixel displaying blue, unlike the blue light blocking layer **231**, to be attached to the entire area of

the upper panel **200**. The blue light transmitting layer **232** transmits only the blue wavelength band and blocks other wavelength bands. The light of the blocked wavelength band is reflected to perform a light recycle. The blue light transmitting layer **232** may also have a hermetic sealing characteristic.

Thereafter, as shown in FIG. **2**, the lower panel **100** is attached below the blue light transmitting layer **232**. The upper polarizer **21** of the lower panel **100** and the blue light transmitting layer **232** of the upper panel **200** may be directly attached to each other or may also be adhered to each other through a separate adhesive.

Referring back to FIG. **1**, the backlight unit **500** is disposed below the lower polarizer **11**, and the backlight unit includes the blue light source **510** and the light guide plate **520**. A plurality of optical films (not shown) may be formed above the light guide plate **520** and below the lower polarizer **11**.

Further, in the exemplary embodiment of FIG. **1**, the blue light source **510** is disposed at one side of the light guide plate **520**, but may be disposed below the lower surface of the light guide plate **520**.

As described above, according to the liquid crystal display, a black and white liquid crystal panel formed on the lower panel **100** has a relatively thin thickness as compared with a typical black and white liquid crystal panel. In the case of the typical liquid crystal panel, the upper polarizer **21** is included as it is, and a transparent substrate such as glass is included to further have a thickness as thick as the thickness of the substrate. As a result, in the liquid crystal display according to the exemplary embodiment of the present invention, a distance between the color filter **230** of the upper panel **200** and the liquid crystal layer **3** of the lower panel **100** is small as compared with the typical liquid crystal display, such that the likelihood of a display deterioration due to parallax is low.

Further, the liquid crystal display according to the exemplary embodiment of the present invention has a wide viewing angle characteristic because the direction of the light is wider by using the quantum dot (QD) color filter **230**.

As described above, display characteristics according to the exemplary embodiment of the present invention will be described with reference to FIGS. **20** to **33**.

FIGS. **20** to **31** are graphs showing characteristics of the liquid crystal display according to an exemplary embodiment of the present invention.

First, a viewing angle characteristic of the liquid crystal display according to an exemplary embodiment of the present invention will be described with reference to FIGS. **20** and **21**.

FIG. **20** shows a wavelength spectrum of blue light and a spectrum of light with a changed wavelength by passing through the red color filter **230R** and the green color filter **230G** respectively, and FIG. **21** shows a viewing angle characteristic of blue light emitted from the backlight and a viewing angle characteristic of light passing through the red color filter **230R** and the green color filter **230G** respectively.

First, as shown in FIG. **20**, light emitted from the blue light source **510** of the backlight unit **500** has a normalized intensity value based on a wavelength of 450 nm. Further, light passing through the red color filter **230R** and the green color filter **230G** has an adjacent normalized intensity value based on a wavelength of 630 nm and an adjacent normalized intensity value based on a wavelength of 530 nm, respectively. Since each normalized intensity value is a wavelength value representing blue, red, or green, in the liquid crystal display according to the exemplary embodi-



ment of the present invention, the colors are displayed based on the corresponding wavelength.

Further, the liquid crystal display according to the exemplary embodiment of the present invention has a wide viewing angle because light supplied from the blue light source **510** is refracted and dispersed on the red quantum dot (QD) particles **230RQD**, the green quantum dot (QD) particles **230GQD**, and the scattering particles **235** to the outside.

FIG. **21** shows viewing angles of light supplied from the blue light source **510** and light which transmits from the red color filter **230R** and the green color filter **230G**. In the light which transmits from the red color filter **230R** and the green color filter **230G**, while the direction of the light is changed in the red quantum dot (QD) particles **230RQD** and green quantum dot (QD) particles, the light flowing to the side increases and as a result, as shown in FIG. **21**, luminance of about 70% to maximum luminance may be shown even at 60 degrees left and right. While light of the blue light source **510** is also shown in FIG. **21** and the viewing angle looks narrow, but actually, since the light transmitting from the transparent color filter **230T** is refracted and dispersed by the scattering particles **235**, the light has a viewing angle similar to the red and green light of FIG. **21**. That is, in the typical liquid crystal display, the direction of light supplied from the light source is not changed, but in the case of using the color filter **230** including a phosphor as in accordance with the exemplary embodiment of the present invention, the direction of the light is changed due to the phosphor (quantum dot particles, scattering particles, or the like), thereby improving the viewing angle at the side.

Hereinafter, light characteristics of the blue light transmitting layer **232** and the blue light blocking layer **231** will be described with reference to FIGS. **22** and **23**.

First, FIG. **22** shows characteristics of the blue light blocking layer **231**. Since the blue light blocking layer **231** blocks the blue light, the blue light blocking layer **231** has a characteristic in which the blue light is not transmitted and reflected. That is, in FIG. **22**, transmission and reflection of the blue light blocking layer **231** are shown together with a wavelength spectrum corresponding to each color. As a result, the blue light blocking layer **231** transmits the red and green lights, but blocks and reflects the blue light.

Referring now to FIG. **23**, a transmission characteristic of the blue light transmitting layer **232** is shown. In FIG. **23**, a characteristic of transmitting adjacent light based on 450 nm is shown. Other light of red and green wavelengths are blocked.

On the basis of the characteristics of FIGS. **22** and **23**, each of the blue light blocking layer **231** and the blue light transmitting layer **232** which are used in the exemplary embodiment of the present invention blocks the blue light so that light of the blue wavelength is not included at a place where the red and green are displayed, and components other than the blue light supplied from the light source are blocked, thereby improving purity of light applied to the color filter **230**.

Hereinafter, a method of preventing a display deterioration due to parallax of the light in the liquid crystal display according to the exemplary embodiment of the present invention will be described in detail with reference to FIGS. **24** to **31**.

First, in FIGS. **24** and **25**, a characteristic of transmitting light according to an incident angle when the blue light is inputted to the blue light transmitting layer **232** of the upper panel **200** is shown.

In FIGS. **24** and **25**, in the case of the incident angle of 0 degree, the blue light is vertically inputted to the blue light transmitting layer **232**, and in the case of the incident angle of 80 degrees, the blue light is inputted at an angle of 80 degrees to a vertical normal to the blue light transmitting layer **232**.

In FIG. **24**, wavelength variation of the transmitting light according to an incident angle is shown, and in FIG. **25**, transmission of the blue light according to an incident angle is shown.

In FIG. **24**, in the case of an incident angle of 0 degree, a wavelength of incident light maintains the blue wavelength band as it is, but as the incident angle increases, the wavelength of the incident light is relatively shorter so as not to be transmitted in the blue light transmitting layer **232**. As a result, only light which is vertically (incident angle of 0 degree) inputted to the blue light transmitting layer **232** is transmitted, and in the case where the incident angle is large, light is not transmitted but reflected in the blue light transmitting layer **232** to be used for the light recycle. Further, in FIG. **25**, in the case of the incident angle of 0 degree, 90% of light emitted from the blue light source **510** of the backlight unit **500** is transmitted, but as the incident angle increases, the transmission of the transmitted light decreases and the remaining light is reflected.

As described above, due to the characteristic of the blue light transmitting layer **232**, only the blue light is transmitted and other wavelength light (light which are obliquely inputted at a predetermined angle or more) are reflected and thus only the same light as vertical light is inputted to the color filter **230**, such that the display deterioration due to parallax does not occur. That is, the parallax is generated when the light transmitting from the adjacent pixel is inputted to the color filter **230** of the corresponding pixel, and the light is obliquely inputted to the blue light transmitting layer **232** so as not to transmit through the blue light transmitting layer **232**, thereby preventing the display deterioration due to parallax.

Parallax will now be described in more detail with reference to FIGS. **26** to **31**.

In FIG. **26**, in order to clearly describe parallax, a circumferential layered relationship is shown. Various cases where light passing through the liquid crystal layer **3** of the lower panel **100** passes through the upper polarizer **21** to be inputted to the color filter **230** are shown, and an expressed color is changed depending on the color of the passed color filter **230**. That is, there is no problem in the case where the light passes through the color filter **230** of the corresponding pixel, but in the case where the light progresses to the side, while the light passes through the adjacent color filter **230**, the display deterioration due to parallax occurs. In the exemplary embodiment of the present invention, the display deterioration due to parallax is somewhat prevented by the blue light transmitting layer **232**, but a value capable of preventing the display deterioration due to parallax regardless of the blue light transmitting layer **232** will be calculated.

In the exemplary embodiment shown in FIG. **26**, a width of the color filter **230** represented by  $W_p$  is 105.5  $\mu\text{m}$ , a width of the light blocking member **220** represented by  $W_b$  is 29  $\mu\text{m}$ , a pixel per inch (PPI) is 63, a pixel size is 403.5  $\mu\text{m}$ , and a sub pixel size is 134.5  $\mu\text{m}$ .

In the exemplary embodiment shown in FIG. **26**, characteristics according to a vertical distance  $d$  between the color filter **230** and the liquid crystal layer **3** and a divergence half angle are shown in FIGS. **27** and **28**.



FIG. 27 shows variation in intensity of light for a viewing angle according to variation in the vertical distance  $d$  between the color filter 230 and the liquid crystal layer 3. The case where the intensity of light is 0 means that the light is blocked by the light blocking member 220 in the corresponding viewing angle and thus the case where the intensity of light becomes 0 and then increases again means that the light progresses to the adjacent color filter 230. Therefore, in FIG. 27, it can be seen that the case where the intensity uniformly decreases is only the case where the vertical distance  $d$  between the color filter 230 and the liquid crystal layer 3 is 10  $\mu\text{m}$ , and as the vertical distance  $d$  between the color filter 230 and the liquid crystal layer 3 is smaller, the likelihood of a display deterioration due to parallax is low.

Further, FIG. 28 shows variation in intensity of the light for a viewing angle according to a divergence half angle in a state where the vertical distance  $d$  between the color filter 230 and the liquid crystal layer 3 is fixed to 200  $\mu\text{m}$ . Even in a graph of FIG. 28, since the case where the intensity of light becomes 0 and then increases again means that the light progresses to the adjacent color filter 230, when the intensity uniformly decreases, the display deterioration due to parallax does not occur. In FIG. 28, it is clearly shown that the case where the display deterioration due to parallax does not occur is only the case where the divergence half angle is 20 degrees, and as the divergence half angle decreases, the display deterioration due to parallax likelihood is low.

Based on the above description, in FIGS. 29 and 30, occurrence frequency of the parallax according to a divergence half angle is shown.

First, in FIG. 29, in the case where a PPI value is 63, the occurrence frequency of the display deterioration due to parallax is measured by changing the vertical distance  $d$  between the color filter 230 and the liquid crystal layer 3. As shown in FIG. 29, the case where the display deterioration due to parallax does not occur is only the case where the vertical distance  $d$  between the color filter 230 and the liquid crystal layer 3 is 10  $\mu\text{m}$ .

Further, in FIG. 30, the occurrence frequency of the display deterioration due to parallax is measured by fixing the vertical distance  $d$  between the color filter 230 and the liquid crystal layer 3 to 200  $\mu\text{m}$  and changing the pixels per inch (PPI). In FIG. 30, the display deterioration due to parallax occurs in all cases, but as the divergence half angle decreases, the display deterioration due to parallax does not occur regardless of the PPI value, and as the PPI value decreases, the pixel size increases and thus the display deterioration due to parallax occurs less.

In the exemplary embodiment of the present invention, to prevent the display deterioration due to parallax, the vertical distance  $d$  between the color filter 230 and the liquid crystal layer 3 becomes smaller. That is, referring to FIG. 2, the upper polarizer 21 has the thickest thickness between the color filter 230 and the liquid crystal layer 3 and the thickness is 100 to 200  $\mu\text{m}$ . Therefore, in the exemplary embodiment of FIG. 2 of the present invention, the vertical distance ( $d$  as seen in FIG. 26) between the color filter 230 and the liquid crystal layer 3 is 100 to 200  $\mu\text{m}$ , and in this case, it is advantageous that the vertical distance  $d$  is reduced sharply because the insulation substrate is not formed therebetween.

As described above, how much the parallax may be improved by sharply reducing the vertical distance  $d$  between the color filter 230 and the liquid crystal layer 3 is shown in FIG. 31.

In FIG. 31, in the case where the divergence half angle is 80 degrees or less and the vertical distance  $d$  between the color filter 230 and the liquid crystal layer 3 is 500  $\mu\text{m}$  or less and in the case where the divergence half angle is 55 degrees or less and the vertical distance  $d$  between the color filter 230 and the liquid crystal layer 3 is 100  $\mu\text{m}$  or less, whether the display deterioration due to parallax occurs is shown.

As shown in FIG. 31, in the case where the vertical distance  $d$  between the color filter 230 and the liquid crystal layer 3 is 500  $\mu\text{m}$  or less, the display deterioration due to parallax occurs several times according to a change of the viewing angle, but in the vertical distance  $d$  between the color filter 230 and the liquid crystal layer 3 is 100  $\mu\text{m}$  or less, the display deterioration due to parallax hardly occurs.

As shown in FIG. 31, in the exemplary embodiment of the present invention, only the upper polarizer 21 is formed as a layer having a large thickness between the color filter 230 and the liquid crystal layer 3 and as a result, the distance is sharply reduced and the display deterioration due to parallax is prevented.

Hereinafter, an exemplary embodiment different from the exemplary embodiment of FIGS. 1 and 2 will be described with reference to FIGS. 32 to 35.

First, another exemplary embodiment will be described with reference to FIGS. 32 to 35.

FIG. 32 is an exploded perspective view of a liquid crystal display according to another exemplary embodiment of the present invention and FIG. 33 is a cross-sectional view of the liquid crystal display according to the exemplary embodiment of FIG. 32.

The exemplary embodiment of FIG. 32 includes an ultraviolet rays light source 510' as a light source as compared with the blue light source 510 of the exemplary embodiment of FIG. 1. As a result, polarizers 11' and 21' have a characteristic of polarizing ultraviolet rays, and an ultraviolet rays blocking layer 231' and an ultraviolet rays transmitting layer 232' are included in the upper panel 200'. Further, quantum dot particles included in a color filter 230' change a wavelength of the ultraviolet rays to be changed into red, green, and blue. Further, in the exemplary embodiment of FIG. 32, an upper polarizer 21' is included in the upper panel 200'.

As shown in FIG. 32, a liquid crystal display according to another exemplary embodiment of the present invention includes a lower panel 100', an upper panel 200', and a backlight unit 500'.

The backlight unit 500' includes an ultraviolet rays light source 510' and a light guide plate 520. The lower panel 100' disposed thereon includes a lower polarizer 11', a lower substrate 110, a wiring layer 111, a liquid crystal layer 3 formed in a microcavity, and an upper insulating layer 310. Further, the upper panel 200' disposed thereon includes an upper polarizer 21', an upper substrate 210, an ultraviolet rays blocking layer 231', a color filter 230', and an ultraviolet rays transmitting layer 232'.

As described above, the liquid crystal display according to the exemplary embodiment of FIG. 32 will be described in more detail with reference to FIG. 33.

First, the lower panel 100 will be described with reference to FIG. 33.

A wiring layer 111 including a thin film transistor (not shown) and the like is formed on a substrate 110 made of transparent glass, plastic, or the like. The wiring layer 111 includes a gate line 121, a storage voltage line 131, a gate insulating layer 140, a data line (not shown), a passivation layer (not shown) and a pixel electrode 190, and the thin film transistor is connected to the gate line 121 and the data line.



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Structures of the pixel electrode **190**, the gate line **121**, and the data line formed on the wiring layer **111** may vary according to an exemplary embodiment.

The gate line **121** and the storage voltage line **131** are disposed below the gate insulating layer **140** and electrically separated from each other, and the data line crosses and is insulated from the gate line **121** and the storage voltage line **131**. The gate electrode on the gate line **121** and the source electrode on the data line provide a control terminal and an input terminal of the thin film transistor, respectively. Further, an output terminal (drain electrode) of the thin film transistor is connected with the pixel electrode **190**, and the pixel electrode **190** is insulated from the gate line **121**, the storage voltage line **131** and the data line.

A support layer **311** is disposed on the pixel electrode **190** and the passivation layer. The support layer **311** serves to support itself so that an inner portion of the support layer **311**, that is, an upper space (hereinafter, referred to as a microcavity (see **305** of FIG. **11**)) of the pixel electrode **190** and the passivation layer may be formed. A cross section of the support layer **311** according to the exemplary embodiment may have a trapezoid shape, and have a liquid crystal injection hole on one side thereof in order to inject a liquid crystal in the microcavity **305**. The support layer **311** may include an inorganic insulating material such as silicon nitride (SiNx) and the like.

Further, in order to arrange liquid crystal molecules injected in the microcavity **305**, an alignment layer **12** is formed at the inside of the support layer **311**, that is, at the upper portion of the pixel electrode **190** and the passivation layer. The alignment layer **12** made of at least one of generally used materials such as polyamic acid, polysiloxane, or polyimide, or the like as a liquid crystal alignment layer may be formed.

The liquid crystal layer **3** is formed under the alignment layer **12** of the microcavity **305**, and the liquid crystal molecules **31** are initially aligned by the alignment layer **12**. A thickness of the liquid crystal layer **3** may be about 5 to 6  $\mu\text{m}$ .

A light blocking member (BM) **220** is formed between the adjacent support layers **311**. The light blocking member **220** includes a material which does not transmit light and has an opening, and the opening may correspond to the microcavity **305**.

A common electrode **270** is formed on the support layer **311** and the light blocking member **220**. The common electrode **270** and the pixel electrode **190** are made of a transparent conductive material such as ITO or IZO and serve to control an alignment direction of the liquid crystal molecules **31** by generating an electric field.

A flattening layer **312** is formed on the common electrode **270**. The flattening layer **312**, as a layer for removing a step generated on the common electrode **270** due to the light blocking member **220**, may include an organic material.

A patterned insulating layer **313** is formed on the flattening layer **312**. The patterned insulating layer **313** may include an inorganic insulating material such as silicon nitride (SiNx). The flattening layer **312** and the patterned insulating layer **313** are patterned together with the support layer **311** to form a liquid crystal injection hole **335**. The patterned insulating layer **313** may be omitted according to an exemplary embodiment. In FIG. **32**, the support layer **311**, the flattening layer **312**, and the patterned insulating layer **313** are shown as one upper insulating layer **310**.

The lower polarizer **11'** is attached to the rear surface of the substrate **110**. The lower polarizer **11'** transmits only one polarization direction of the ultraviolet rays. Further, the

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lower polarizer **11'** may not be thinly formed and includes a polarization element generating polarization and a Triacetyl-cellulose (TAC) layer for ensuring durability.

The upper panel **200'** will now be described.

The upper panel **200'** is disposed on the patterned insulating layer **313**.

Referring to FIGS. **32** and **33**, in the upper panel **200'**, the ultraviolet rays blocking layer **231'** is formed below the upper substrate **210** made of transparent glass, plastic, or the like

The ultraviolet rays blocking layer **231'** is formed on all pixel areas displaying blue, red, and green. The ultraviolet rays blocking layer **231'** may be formed by alternately laminating at least two layers having different refractive indexes, and wavelengths except for an ultraviolet wavelength band are transmitted and the ultraviolet wavelength band is blocked. The blocked ultraviolet rays are reflected and thus a light recycle may also be performed. The ultraviolet rays blocking layer **231'** serves to block light emitted from an ultraviolet rays light source **510'** from being directly emitted outside.

An upper light blocking member **221** is formed below the upper substrate **210** and the ultraviolet rays blocking layer **231'**. The upper light blocking member **221** also has an opening, and a color filter **230'** corresponding to a color displayed in the corresponding pixel is formed.

First, a red color filter **230R'** is formed in a red pixel, a green color filter **230G'** is formed in a green pixel, and a blue color filter **230B'** is formed in a blue pixel.

The red color filter **230R'** may include red quantum dot (QD) particles **230RQD'** and converts light having a wavelength supplied in the ultraviolet rays light source **510'** into red.

Further, the green color filter **230G'** may include green quantum dot (QD) particles **230GQD'** and converts light having a wavelength supplied in the ultraviolet rays light source **510'** into green.

In addition, the blue color filter **230B'** may include blue quantum dot (QD) particles **230BQD'** and converts light having a wavelength supplied in the ultraviolet rays light source **510'** into blue.

In the exemplary embodiment of the present invention, since the light supplied in the ultraviolet rays light source **510'** of the backlight is converted into red, green, and blue light in the red quantum dot (QD) particles **230RQD'**, the green quantum dot (QD) particles **230GQD'**, and the blue quantum dot (QD) particles **230BQD'**, respectively, and then emitted outside to display an image, the direction of the light emitted outside is wide and grays of the light are not changed according to a viewing position, such that the light may have a wide viewing angle.

An upper flattening layer **250** is formed below the upper light blocking member **221**, the red color filter **230R'**, the green color filter **230G'**, and the blue color filter **230B'**. The upper flattening layer **250** may be made of an organic material and may also be omitted according to an exemplary embodiment.

The ultraviolet rays transmitting layer **232'** is formed below the upper flattening layer **250** and formed in all the pixel areas like the ultraviolet rays blocking layer **231'**. The ultraviolet rays transmitting layer **232'** may also be formed by alternately laminating at least two layers having different refractive indexes, and transmits only the ultraviolet wavelength band and blocks other wavelength bands. The light of the blocked wavelength bands is reflected and thus a light recycle may be performed.



The upper polarizer **21'** is disposed below the ultraviolet rays transmitting layer **232'**. The upper polarizer **21'** transmits only one polarization direction of the ultraviolet rays. Further, the upper polarizer **21'** may be thinly formed and have a thickness of 150 to 200  $\mu\text{m}$ . The upper polarizer **21'** includes a polarization element generating polarization and a Tri-acetyl-cellulose (TAC) layer for ensuring durability.

The lower panel **100'** is disposed below the upper polarizer **21'** and the patterned insulating layer **313** which is the uppermost layer of the lower panel **100'** and the upper polarizer **21'** may be directly attached to each other or may also be adhered to each other through a separate adhesive.

When comparing the exemplary embodiments of FIGS. **1** and **32**, the upper polarizers **21**, **21'** may include the upper panel or the lower panel, the upper panel may be disposed above the upper polarizers **21**, **21'**, and the lower panel may be disposed below the upper polarizers **21** and **21'**.

Referring back to FIG. **32**, the backlight unit **500'** is disposed below the lower polarizer **11**, and the backlight unit includes the ultraviolet rays light source **510'** and the light guide plate **520**. A plurality of optical films (not shown) may be formed above the light guide plate **520** and below the lower polarizer **11**.

As described above, in the liquid crystal display, the substrate is not additionally included and thus the thickness is thin. As a result, in the liquid crystal display according to the exemplary embodiment of the present invention, a distance between the color filter **230'** of the upper panel **200** and the liquid crystal layer **3** of the lower panel **100** is small as compared with the typical liquid crystal display, such that a the likelihood of display deterioration due to parallax is low.

Further, the liquid crystal display according to the exemplary embodiment of the present invention has a wide viewing angle characteristic because the direction of the light is wider by using the quantum dot (QD) color filter **230'**.

Hereinafter, yet another exemplary embodiment will be described with reference to FIGS. **34** and **35**.

FIG. **34** is an exploded perspective view of a liquid crystal display according to yet another exemplary embodiment of the present invention and FIG. **35** is a cross-sectional view of the liquid crystal display according to the exemplary embodiment of FIG. **34**.

The exemplary embodiment of FIGS. **34** and **35** includes an ultraviolet rays light source **510'** as a light source unlike the exemplary embodiment of FIG. **1**. A lower polarizer **11'** has a characteristic of polarizing ultraviolet rays, and an upper polarizer **21-1** has a characteristic of polarizing light because a metal wirings **21-2** such as aluminum and the like are disposed with an interval of 100 nm or less in order to reduce the thickness. In the exemplary embodiment of FIGS. **34** and **35**, since the upper polarizer **21** is not formed, but the polarizer including the metal wirings is used, the thickness of the polarizer may be decreased to about 5 to 10  $\mu\text{m}$ , thereby largely reducing the parallax likelihood.

Further, an ultraviolet rays blocking layer **231'** is included in the upper panel **200**. Further, quantum dot particles included in a color filter **230'** change a wavelength of the ultraviolet rays to be changed into red, green, and blue. Further, in the exemplary embodiment of FIGS. **34** and **35**, all layers are laminated on one substrate to be configured as one display panel.

As shown in FIGS. **34** and **35**, a liquid crystal display according to another exemplary embodiment of the present invention includes a display panel **100''** and a backlight unit **500'**.

The backlight unit **500'** includes an ultraviolet rays light source **510'** and a light guide plate **520**. The display panel **100''** disposed thereon includes a lower polarizer **11'**, a lower substrate **110**, a liquid crystal layer **3** formed in a microcavity, and an upper insulating layer **310**, an upper polarizer **21-1**, a color filter **230'**, an ultraviolet rays blocking layer **231'**. In the exemplary embodiment of FIGS. **35** and **36**, unlike the exemplary embodiment of FIG. **33**, an ultraviolet rays transmitting layer is omitted.

Integrated display panel **100''** will now be described in more detail with reference to FIG. **35**.

A wiring layer **111** including a thin film transistor (not shown) and the like is formed on a substrate **110** made of transparent glass, plastic, or the like. The wiring layer **111** includes a gate line **121**, a storage voltage line **131**, a gate insulating layer **140**, a data line (not shown), a passivation layer (not shown) and a pixel electrode **190**, and the thin film transistor is connected to the gate line **121** and the data line. Structures of the pixel electrode **190**, the gate line **121**, and the data line formed on the wiring layer **111** may vary according to an exemplary embodiment.

The gate line **121** and the storage voltage line **131** are disposed below the gate insulating layer **140** and electrically separated from each other, and the data line crosses the gate line **121** and the storage voltage line **131** and is insulated therefrom. The gate electrode on the gate line **121** and the source electrode on the data line configure a control terminal and an input terminal of the thin film transistor, respectively. Further, an output terminal (drain electrode) of the thin film transistor is connected with the pixel electrode **190**, and the pixel electrode **190** is insulated from the gate line **121**, the storage voltage line **131** and the data line.

A support layer **311** is disposed on the pixel electrode **190** and the passivation layer. The support layer **311** serves to support the pixel electrode **190** and the passivation layer so that an inner portion of the support layer **311**, that is, an upper space (hereinafter, referred to as a microcavity (see **305** of FIG. **11**)) of the pixel electrode **190** and the passivation layer may be formed. A cross section of the support layer **311** according to the exemplary embodiment may have a trapezoid shape, and have a liquid crystal injection hole on one side thereof in order to inject a liquid crystal in the microcavity **305**. The support layer **311** may include an inorganic insulating material such as silicon nitride ( $\text{SiN}_x$ ) and the like.

Further, in order to arrange liquid crystal molecules injected in the microcavity **305**, an alignment layer **12** is formed at the inside of the support layer **311**, that is, at the upper portion of the pixel electrode **190** and the passivation layer. The alignment layer **12** made of at least one of generally used materials such as polyamic acid, polysiloxane, or polyimide, or the like as a liquid crystal alignment layer may be formed.

The liquid crystal layer **3** is formed under the alignment layer **12** of the microcavity **305**, and the liquid crystal molecules **31** are initially aligned by the alignment layer **12**. A thickness of the liquid crystal layer **3** may be about 5 to 6  $\mu\text{m}$ .

A light blocking member **220** is formed between the adjacent support layers **311**. The light blocking member **220** includes a material which does not transmit light and has an opening, and the opening may correspond to the microcavity **305**.

A common electrode **270** is formed on the support layer **311** and the light blocking member **220**. The common electrode **270** and the pixel electrode **190** are made of a transparent conductive material such as ITO or IZO and



serve to control an alignment direction of the liquid crystal molecules **31** by generating an electric field.

A flattening layer **312** is formed on the common electrode **270**. The flattening layer **312**, as a layer for removing a step generated on the common electrode **270** due to the light blocking member **220**, may include an organic material.

A patterned insulating layer **313** is formed on the flattening layer **312**. The patterned insulating layer **313** may include an inorganic insulating material such as silicon nitride (SiNx). The flattening layer **312** and the patterned insulating layer **313** are patterned together with the support layer **311** to form a liquid crystal injection hole **335**. The patterned insulating layer **313** may be omitted according to an exemplary embodiment. In FIG. **34**, the support layer **311**, the flattening layer **312**, and the patterned insulating layer **313** are shown as one upper insulating layer **310**.

The upper polarizer **21-1** is disposed on the patterned insulating layer **313**. The upper polarizer **21-1** has a characteristic of polarizing light because a metal wirings **21-2** such as aluminum and the like are disposed with an interval of 100 nm or less in order to reduce the thickness. In the exemplary embodiment of FIGS. **34** and **35**, since the upper polarizer **21** is not formed, but the polarizer including the metal wirings is used, the thickness of the polarizer may be decreased to about 5 to 10  $\mu\text{m}$ , thereby largely reducing the parallax likelihood.

An upper light blocking member **221** is formed on the upper polarizer **21-1**. The upper light blocking member **221** also has an opening, and a color filter **230'** corresponding to a color displayed in the corresponding pixel is formed.

First, a red color filter **230R'** is formed in a red pixel, a green color filter **230G'** is formed in a green pixel, and a blue color filter **230B'** is formed in a blue pixel.

The red color filter **230R'** may include red quantum dot (QD) particles **230RQD'** and converts light having a wavelength supplied by the ultraviolet rays light source **510'** into red.

Further, the green color filter **230G'** may include green quantum dot (QD) particles **230GQD'** and converts light having a wavelength supplied by the ultraviolet rays light source **510'** into green.

In addition, the blue color filter **230B'** may include blue quantum dot (QD) particles **230BQD'** and converts light having a wavelength supplied by the ultraviolet rays light source **510'** into blue.

In the exemplary embodiment of the present invention, since the light supplied by the ultraviolet rays light source **510'** of the backlight is converted into red, green, and blue light in the red quantum dot (QD) particles **230RQD'**, the green quantum dot (QD) particles **230GQD'**, and the blue quantum dot (QD) particles **230BQD'**, respectively, and then emitted outside to display an image, the direction of the light emitted outside is wide and grays of the light are not changed according to viewing position, such that the light may have a wide viewing angle.

An upper flattening layer **250** is formed on the upper light blocking member **221**, the red color filter **230R'**, the green color filter **230G'**, and the blue color filter **230B'**. The upper flattening layer **250** may be made of an organic material and may also be omitted according to an exemplary embodiment.

An ultraviolet rays blocking layer **231'** is formed on the upper flattening layer **250**. The ultraviolet rays blocking layer **231'** is formed on all pixel areas displaying blue, red, and green. The ultraviolet rays blocking layer **231'** may be formed by alternately laminating at least two layers having different refractive indexes, and wavelengths except for an

ultraviolet wavelength band are transmitted and the ultraviolet wavelength band is blocked. The blocked ultraviolet rays are reflected and thus a light recycle may also be performed. The ultraviolet rays blocking layer **231'** serves to block light emitted from an ultraviolet rays light source **510'** from being directly emitted outside.

The lower polarizer **11'** is attached to the rear surface of the substrate **110**. The lower polarizer **11'** transmits only a polarization direction of one direction of the ultraviolet rays. Further, the lower polarizer **11'** need not be thinly formed and includes a polarization element generating polarization and a Tri-acetyl-cellulose (TAC) layer for ensuring durability.

Referring back to FIG. **34**, the backlight unit **500'** is disposed below the lower polarizer **11**, and the backlight unit includes the ultraviolet rays light source **510'** and the light guide plate **520**. A plurality of optical films (not shown) may be formed above the light guide plate **520** and below the lower polarizer **11**.

That is, in the exemplary embodiment of FIGS. **34** and **35**, the thickness of the entire liquid crystal display is reduced by using only one substrate **110** and the upper polarizer **21-1** disposed between the liquid crystal layer **3** and the color filter **230'** is changed into the structure including the metal wirings to largely reduce the thickness, thereby largely reducing the parallax likelihood.

Further, the liquid crystal display according to the exemplary embodiment of the present invention has a wide viewing angle characteristic because the direction of the light is wider by using the quantum dot (QD) color filter **230'**.

While this invention has been described in connection with what is presently considered to be practical exemplary embodiments, it is to be understood that the invention is not limited to the disclosed embodiments, but, on the contrary, is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims.

What is claimed is:

**1.** A liquid crystal display, comprising:

a backlight unit comprising a light source comprising a blue light source;

a display panel comprising:

a first substrate and a second substrate;

a liquid crystal layer disposed between the first substrate and the second substrate;

a color filter disposed on the second substrate, the color filter comprising a first color filter comprising a red quantum dot particle, a second color filter comprising a green quantum dot particle, and a third color filter comprising a transparent organic material and scattering particles therein;

a blue light blocking layer disposed on the second substrate and overlapping the first color filter and the second color filter; and

a blue light transmitting layer disposed between the color filters and the liquid crystal layer, wherein the blue light blocking layer and the third color filter are disposed on the same surface of the second substrate,

wherein the red quantum dot particle is disposed between the blue light transmitting layer and the blue light blocking layer,

wherein the green quantum dot particle is disposed between the blue light transmitting layer and the blue light blocking layer, and



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wherein a light emitted from a region overlapping the first color filter passes through the blue light transmitting layer, the first color filter, the blue light blocking layer and the second substrate in this order.

2. The liquid crystal display of claim 1, wherein:  
the blue light blocking layer does not overlap the third color filter.

3. The liquid crystal display of claim 1, wherein the blue light transmitting layer disposed between the color filter and the liquid crystal layer overlaps the first color filter, the second color filter and the third color filter.

4. The liquid crystal display of claim 3, wherein:  
the blue light transmitting layer transmits light in a blue wavelength band and reflects light in the other wavelength bands.

5. The liquid crystal display of claim 4, wherein:  
the blue light transmitting layer comprises at least two layers having different refractive indexes.

6. The liquid crystal display of claim 1, further comprising:  
a lower polarizer disposed between the backlight unit and the first substrate; and  
an upper polarizer disposed between the liquid crystal layer and the color filter.

7. A liquid crystal display, comprising:  
a backlight unit comprising a light source comprising a blue light source;  
a display panel comprising:  
a first substrate and a second substrate;  
a liquid crystal layer disposed between the first substrate and the second substrate;  
a color filter disposed on the second substrate, the color filter comprising a first color filter comprising a red quantum dot particle, a second color filter comprising a green quantum dot particle, and a third color filter comprising a transparent organic material;

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a blue light blocking layer disposed on the second substrate and overlapping the first color filter and the second color filter; and  
a blue light transmitting layer disposed between the color filter and the liquid crystal layer and overlapping the first color filter, the second color filter and the third color filter,  
wherein the blue light blocking layer and the third color filter are disposed on the same surface of the second substrate,  
wherein the blue light transmitting layer comprises at least two layers having different refractive indexes  
wherein the red quantum dot particle is disposed between the blue light transmitting layer and the blue light blocking layer,  
wherein the green quantum dot particle is disposed between the blue light transmitting layer and the blue light blocking layer, and  
wherein a light emitted from a region overlapping the first color filter passes through the blue light transmitting layer, the first color filter, the blue light blocking layer and the second substrate in this order.

8. The liquid crystal display of claim 7, wherein:  
the at least two layers having different refractive indexes are laminated alternately.

9. The liquid crystal display of claim 7, wherein:  
the blue light blocking layer does not overlap the third color filter.

10. The liquid crystal display of claim 7, wherein:  
the blue light transmitting layer transmits light in a blue wavelength band and reflects light in the other wavelength bands.

11. The liquid crystal display of claim 7, further comprising:  
a lower polarizer disposed between the backlight unit and the first substrate; and  
an upper polarizer disposed between the liquid crystal layer and the color filter.

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